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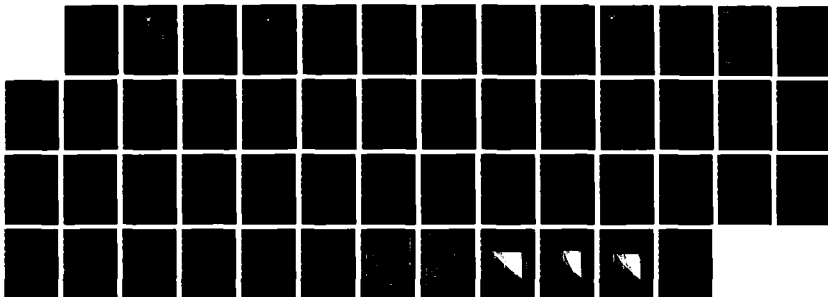
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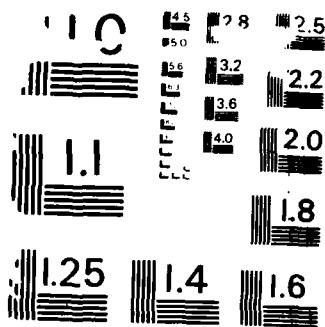
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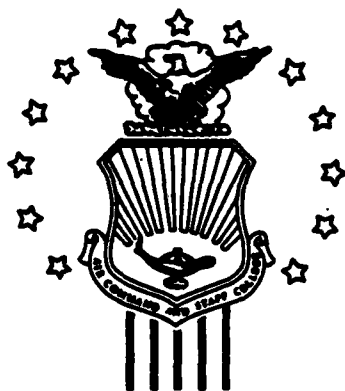


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# AIR COMMAND AND STAFF COLLEGE

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STRATEGIC OFFENSIVE AIRPOWER:  
THE ROLE OF THE LONG RANGE BOMBER

MAJOR ARCH L. MOBERLY

88-1860

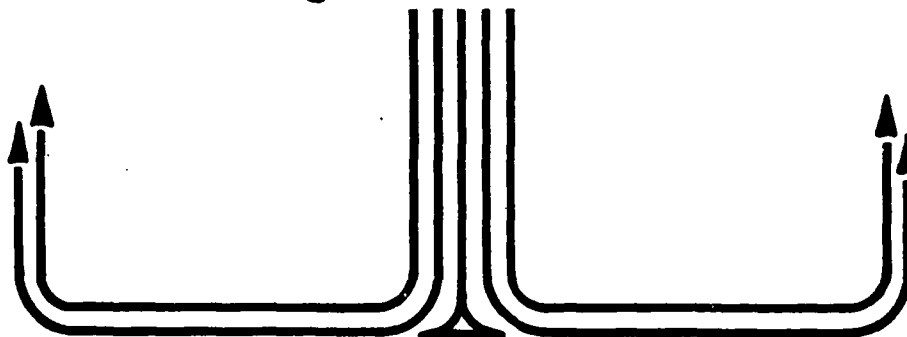
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**REPORT NUMBER** 88-1860  
**TITLE** STRATEGIC OFFENSIVE AIRPOWER: THE ROLE OF THE LONG RANGE BOMBER

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**SPONSOR** COL T. F. ATKINSON  
JOINT FLAG OFFICER WARFIGHTING COURSE  
CADRE/SO

Submitted to the faculty in partial fulfillment of  
requirements for graduation.

**AIR COMMAND AND STAFF COLLEGE**  
**AIR UNIVERSITY**  
**MAXWELL AFB, AL 36112-5542**

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SECURITY CLASSIFICATION OF THIS PAGE

A194-060

## REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION/AVAILABILITY OF REPORT STATEMENT "A" Approved for public release; Distribution is unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 88-1860			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION ACSC/EDC		6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) MAXWELL AFB AL 36112-5542			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
11. TITLE (Include Security Classification) STRATEGIC OFFENSIVE AIRPOWER: THE ROLE OF THE LONG RANGE BOMBER					
12. PERSONAL AUTHOR(S) Moberly, Arch L., Major, USAF					
13a. TYPE OF REPORT		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1988 April	
15. PAGE COUNT					
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP			
19. ABSTRACT (Continue on reverse if necessary and identify by block number)  The proposal to create a long range strategic conventional bomber force adds a new dimension to airpower employment in NATO. The heavy bomber has a range and payload capability which permits holding distant high value enemy targets at risk. The study examines reasons why this new bomber force should be employed outside the current air attack philosophy and finds that such use would increase deterrence and contribute to successful warfighting should deterrence fail. In addition, the analysis identifies critical target systems within the USSR and considers force employment requirements for a strategic offensive air campaign.					
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION		
22a. NAME OF RESPONSIBLE INDIVIDUAL ACSC/EDC Maxwell AFB AL 36112-5542			22b. TELEPHONE (Include Area Code) (205) 293-2867		22c. OFFICE SYMBOL

## PREFACE

In 1986, the Strategic Air Command started to re-emphasize the capability to deliver non-nuclear munitions. The conventional role of the command has a proud history, starting with the devastation created by Eighth and Fifteenth Air Force B-17s and B-24s during World War II had a decisive impact on the termination of the European conflict. Similarly, the Korean War was an extremely short but effective offensive attack which eliminated the limited industrial capability of North Korea. Although after Korea the bombers grew into a primary element of the nuclear TRIAD, the conventional role was never totally abandoned.

Most members of today's Air Force probably best remember the use of strategic conventional aircraft in Vietnam. In the late 60s, the surprise and lethality of the B-52D ARC LIGHT strikes in South Vietnam came to epitomize US airpower. Later, the ferocity of the 1972 Christmas bombing offensive (LINEBACKER II) emphasized the potential of the heavy bomber to concentrate force in a short period to achieve national political goals. After Vietnam, with few exceptions, conventional operations were not viewed as a primary mission and command capabilities declined because of resource scarcity and urgent modernization requirements for nuclear forces.

The need for a conventional projection capability re-surfaced with the return to military operations such as Grenada, Libya, and Lebanon as instruments of national policy. This need was further reinforced by the growing realization that reducing nuclear arms could make conventional conflict more likely. The capabilities of the long range bomber were like no other aircraft available and offered the further advantage of being fully developed assets that could be used on short notice.

In Europe, and especially in the Central Region, NATO created an airpower employment concept which relies on their short range tactical forces to achieve the objective. Although very capable forces, tactical aircraft have substantially different characteristics from strategic airpower. Properly incorporating long range bombers into NATO to produce the maximum combat results is a challenge for both. Working together to achieve a common objective does not necessarily have to mean operating in the same airspace. This paper provides background research supporting enhancing the present concept by a combined tactical and strategic attack which capitalizes on each force's unique features.

Examining the history of strategic airpower employment, two elements emerge which are common with NATO's present requirements: The ability to disrupt transportation networks at long range and the ability to destroy the war sustaining capacity of an enemy. The strategic aerospace offensive and deep interdiction proposed in this paper is one option which should not be casually discarded as an outmoded concept. The Warsaw Pact has significant vulnerabilities which can be exploited by long range airpower to increase deterrence in the European theater.

The paper is sponsored by the Center for Aerospace Doctrine, Research, and Education. Parts of the material may be incorporated into the Joint Flag Officers' Warfighting Course.

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## ABOUT THE AUTHOR

Major Arch L. Moberly is a targeting officer with an extensive background in tactical and strategic force planning. In both areas his assignments range from direct unit support at wing level to operational theater war planning. As a Tactical Air Command operational intelligence and targeting officer, he ensured three fighter squadrons which specialized in precision ordinance delivery were ready for rapid reaction to three NATO Allied Tactical Air Forces. In addition, he created special Southwest Asia target studies for Readiness Command (USREDCOM) during the early phases of Rapid Deployment Joint Task Force (RDJTF) creation. His two years at 314 Air Division Headquarters provided a perspective on Tactical Air Control Center operations and Joint/Combined force planning for defense of the Republic of Korea. Returning from Korea in 1987, he spent the next four years at the Strategic Air Command headquarters working both conventional and nuclear issues. As a member of the Joint Strategic Target Planning Staff (JSTPS), he was the National Strategic Target List (NSTL) Directorate's senior analyst evaluating Single Integrated Operational Plan (SIOP) damage for the Joint Chiefs of Staff (JCS) and the National Command Authority (NCA). At the same time, Major Moberly mobilized as a member of the SAC Advanced Echelon (ADVON) for conventional operations in Europe and Southwest Asia. In 1997, he was chief of the command's Contingency Target Development Branch, providing targeting support for worldwide conventional JCS crisis planning. During this period SAC refocused on non-nuclear delivery capabilities. Since 1981, he has planned for the integration and employment of the strategic bomber in every major conventional theater (Korea, Southwest Asia, and Europe), independent contingencies, and in the full spectrum of nuclear operations. Major Moberly was a B-52 navigator before transferring into Intelligence. He is currently completing a Master's degree in International Relations. Major Moberly is a Distinguished Graduate of Squadron Officer's School and is presently attending the Air Command and Staff College.



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### REPORT NUMBER

88-1860

### AUTHOR(S)

MAJOR ARCH L. MOBERLY, USAF

### TITLE

STRATEGIC OFFENSIVE AIRPOWER: THE ROLE OF THE LONG RANGE BOMBER

I. PURPOSE: To analyze Soviet vulnerabilities to strategic airpower and determine if there are credible reasons to employ conventional long range aircraft beyond the present NATO attack philosophy.

II. PROBLEM: The creation of a purely conventional long range bomber force which has significant combat power provides an opportunity to enhance NATO capabilities. Where NATO can best employ this airpower is subject to debate. The bomber's firepower is unquestioned and its all-weather/night capability would help resolve continuing NATO deficiencies in maintaining a constant attack on the advancing Pact forces. On the other hand, the bomber has tremendous range which it sacrifices by staying in the tactical employment arena. Combining range and payload could be of value if the attacks can be directed at important targets maximizing the combined damage of tactical and strategic forces and contributing directly to winning a short duration war.

III. DISCUSSION. Presently NATO has only two military objectives: deter war or win. The current employment strategy which seeks to erode advancing forces and delay their entry into battle is given very little chance of achieving either objective. A credible long range bomber employment plan will expand conventional alternatives to hold down the risk of nuclear war. At the same time, deep interdiction can contribute to front line success by creating significant disruption and delay in the rear areas. The best counter to Soviet numeric superiority in NATO is to make the leaders of the USSR uncertain of the success of military action and very certain that war will

## CONTINUED

bring devastation to key sectors of their economy.

**IV. FINDINGS AND CONCLUSIONS:** Deterring the Soviet Union from aggression requires holding their most valuable possession, the motherland, at risk.

Planning to fight a short-duration war is fighting on Soviet terms. Prolonging the Warsaw Pact advance increases the friction throughout the Soviet war machine. They equate loss of tempo with certain loss of the initiative. Soviet procedures demand a continuous flow of logistics out of the USSR to sustain the offensive.

The Soviet economy was built for output, not protection. Most of the critical systems main components are in the western USSR within range of the B-52s and advanced bombers. The target systems generally consist of a few very large facilities. The most important systems are power, rail transport, and basic industries (oil and steel). Successful attacks can degrade output to a level considered economically non-productive.

Attacking deep targets causes the enemy to slow production, disperse defenses, and retain people and supplies to serve as a repair force. Repair on major facilities should be measured in months or years, not days. Soviet recovery from the priority attack could take 2-5 years minimum, and some facilities might be unrecoverable in less than 10 years.

Priority 1 targets require 600 sorties for effective disruption. Adding second priority installations increases sorties to about 1550, with 2300 sorties needed to cover all targets. Comparing these effects with the last great strategic air offensive, each B-52 can deliver the same number of effective weapons as about 20 B-17s. At a 4% sustained loss rate (four times the observed attrition in air combat), 150 B-52s cover priority 1 and most priority 2 targets in just 15 missions, providing a high-impact air campaign to balance the short-duration attack scenario.

The USSR has significant vulnerabilities that can be quickly exploited by long-range bombers. These vulnerabilities will increase as the Soviets concentrate more of their industry in the western portions of the country. A deep interdiction battle can swiftly spread damage over a wide area, disrupting reserve movement and the logistics flow to help NATO regain the offensive. To accomplish this mission, attacking aircraft must be better armed to minimize the risk of penetrating Soviet airspace, including carrying active defensive weapons and standoff precision ordnance.

**V. RECOMMENDATION:** NATO should prepare to use conventional bombers in an early deep attack against key Soviet power and rail targets, followed with attacks on the high value basic industries and the key secondary industrial systems. Plans to attack deeply should be accompanied by plans to increase bomber self-protection measures. To achieve maximum deterrence, the Russians must know that conflict places their homeland in immediate conventional danger.



FIGURE 1. Strategic Aircraft Range

## STRATEGIC OFFENSIVE AIRPOWER: The Role of the Long Range Bomber

Employing large numbers of heavy bombers in conventional combat presents a new, dynamic force that should dramatically expand European theater warfighting concepts and decrease the likelihood of armed conflict between NATO and the Warsaw Pact. The possibility of a non-nuclear long range attack force received widespread public attention in September 1987, when General Chain (Commander-in-Chief, Strategic Air Command (CINCSAC)) proposed conversion of all 150 B-52G aircraft to purely conventional roles (14:1). This announcement followed an earlier interview with Air Force Magazine, in which the SAC Deputy Chief of Staff/Plans outlined initiatives to modify the remaining 84 B-52H, 50 FB-111, and the 232 B1/B2 (Stealth) advanced bombers for both nuclear and conventional operations (16:1).

The unique combat strengths of these aircraft represent a formidable addition to current non-nuclear forces. As former CINCSAC, General Davis noted, "Long range air provides a heavy payload, all weather day/night firepower delivery capability that no other US weapon system can match" (8:50). Specifically, each B-52 can deliver 51 weapons (i.e., 19 tons of ordnance, about 4 times an F-111 load and 9 times that of an F-16) anywhere in the Warsaw Pact including almost all the European portion of the USSR (Figure 1) (16:--; 14:7). This new long range conventional capability needs an equally unique employment concept that extends beyond present theater airpower philosophies to ensure the maximum combined effect of both strategic and tactical aircraft in degrading Warsaw Pact combat potential.

A most traditional alternative employment concept sends the bombers into the heartland of the USSR, early in a NATO conflict, in a combined strategic aerospace offensive/deep interdiction campaign. The first section of the paper outlines reasons to modify the present air employment concept and develops enhanced air campaign objectives supporting the Theater commander's missions of deterrence or combat success. The next section identifies the scope and location of vital target systems within the western Soviet Union which are vulnerable to today's weapons and the proposed weaponry of future bombers. The final section examines force/employment factors such as required target damage and the impact of enemy defenses and projects the size and duration of a potential air campaign as well as the enemy's prospects for recovery. Overall, this analysis shows that available strategic conventional forces can achieve important theater-level objectives through attacks on a limited target base that is beyond the consistent operational radius of present tactical aircraft.

### RATIONALE FOR CHANGE

Employing strategic airpower beyond current tactical aircraft capabilities can raise the cost of hostilities for the Soviet Union above the projected benefits of aggression and help restore the initiative to friendly forces. So long as deterrence remains NATO's primary goal (12:17-21), the alliance should present the Warsaw Pact with the most difficult combat problem possible. By

consistently optimizing its air employment policy to incorporate new capabilities, NATO achieves the best defense and the best air campaign should deterrence fail. As Gen Giulio Douhet, one of the original proponents of strategic airpower, advised his countrymen ". . . how shall we defend ourselves? My answer has always been by attacking" (45:1). In this spirit, the addition of 150 long range bombers (and perhaps some of the other dual-role aircraft) into the NATO conflict offers the opportunity to supplement existing short range air attacks and thereby make conventional deterrence more credible.

The most compelling reason to project strategic airpower as deeply as possible into the USSR is to threaten the Warsaw Pact's highest value and most important targets. Raising the cost of conventional attack without invoking immediate nuclear response increases the deterrent value of NATO's non-nuclear military presence. According to former Secretary of Defense Weinberger, Soviet leaders will be "more careful in deciding on aggression if they place a wide range of their assets at risk. . . . [T]o offset the enemy's attack, [a counterattack] should be launched against territory or assets that are of an importance to him comparable to the one's he is attacking" (44:4). The scope and vulnerability of such high value target systems are discussed in the second portion of this analysis.

In comparison, the present conventional air/ground employment concept does not look for long range deterrence. Instead this concept first seeks limited air superiority, and then proposes to thwart the enemy's advance by delaying and attriting his second echelon forces (29:28). In fact, this attrition tactic is given little chance of halting the Pact advance, and thus encourages eventual escalation to nuclear war, NATO's ultimate measure of deterrence. For example, General Chain suggested that "only 7 to 10 days would elapse before they [NATO] would be overrun" (14:7). In 1986, the commander of Second Allied Tactical Air Forces (2ATAF) Air Marshall Sir Patrick Hine was only slightly more optimistic, "I do not see how an all-out conventional war could last much beyond 3-4 weeks" (29:25).

Unfortunately, Soviet theater campaign desires match these friendly estimates of a short duration conventional war very well. The Soviet's project (from World War II experience) that the "high-speed offensive operation" (17:3) necessary to quickly defeat NATO would produce 3 times fewer casualties and 1.5 times fewer tank losses than slower advances (16:97). Therefore, their larger forces are deployed in echeloned waves (39:45-55) to achieve "deep penetration of NATO's defense in the first few days of the war" (17:3). If the Pact attacks are successful, former Defense Minister, Marshall Ustinov said they would "hope to win without the use of nuclear weapons" (17:3). However, as projected by one of the Secretary of Defense's senior Soviet analysts, if "confronted with a NATO decision to conduct a [retaliatory] mass nuclear strike, it should be expected that the Soviets would attempt a pre-emptive mass nuclear strike of their own" (17:3). If its capabilities are fully exploited, the range of strategic conventional airpower provides the opportunity to counter the Soviet desires with an intermediate alternative to nuclear response.

Another reason to augment the current employment concept is that using the heavy bomber force at extended range provides alternative attacks which significantly complicate both the Warsaw Pact offensive planning and defense problem. Present conventional tactics apply alliance air strength against enemy ground strength (12:24-28). Using strategic airpower like its tactical

counterpart to directly attack advancing Soviet force concentrations or front logistics would be consistent with the current philosophy. While NATO controls 3525 offensive aircraft (40:92), most of them are incapable of sustained operations beyond the Eastern European states of the Warsaw Pact (i.e., a combat radius under 600 nautical miles (NM) (40:78)). Within these range constraints, facing the threat presented by larger Warsaw Pact forces, NATO evolved a follow-on forces attack providing maximum tactical airpower support to the corps commander. Attempting to control the second echelon unit reinforcements and logistics flow, this support concentrates airpower in a deep attack zone which only ranges from 80 to 160 NM beyond the battle area (12:22). Although, 150 B-52Gs will add only 4% to the overall numbers of NATO offensive aircraft, the bomber's heavy payload, capacity for large area destruction, and all-weather capability are attractive additions for the outnumbered forces in NATO (28:39).

While the emphasis on the immediate battle may be valid for tactical airpower, it should be resisted when adding aircraft with the potential of heavy bombers. In comparison to the F-111's advertised 600 NM radius, the B-52 can fly 4300 NM (40:36) including 1000 NM at low level (14:7). Using the bombers exclusively in the immediate rear areas of the enemy forces perpetuates the limited scope of conventional conflict and the focus on ground support via "massive firepower" seen in Vietnam (11:48). Yet as Secretary Weinberger noted, to better deter a European war the conflict must be planned and fought on a much wider battlefield. This is easier for a commander to accept than to practice for "when faced with an offensive that is either progressing well or seems on the verge of doing so. The tendency is to throw everything against the ground movement and to stop. . . interdiction operations until the emergency is over. This tendency, although natural, may be deadly. . . [because the enemy] will realize the advantages accruing to the offense." (43:102). Instead of B-52s responding directly to the enemy's advances, the commander should employ strategic airpower as a first counterattack to disrupt the enemy's vulnerable points and degrade hostile force movement at the maximum distance from the battlefield.

At the same time, shackling strategic airpower to an tactical area encompassing less than 10% of its total capability eliminates significant enemy problems such as dispersed defenses to cover a wide area and the fear of attack when moving strategic logistics. Albert Speer, Hitler's primary industrial leader, reported that the deep attacks of Allied long range airpower cost Germany 10,000 anti-tank guns (used as AAA), over one-third of both the electronics and optics industries, and a million men dedicated to home and defense (41:127). In addition, he also told post-war investigators that the 75% disruption of Germany's internal transportation network was a key factor in degrading logistic resupply and unit transfers between critical sectors of both fronts (15:14).

The combination of extended threat and tactical aircraft's normal range limitations, puts the theater commander in a situation analogous to the Indian warrior locked in hand-to-hand combat with a grizzly bear. Focused on the massive claws and teeth of the bear, the warrior finds his knife doesn't quite have the reach, nor does he have the opportunity, to attack the bear's heart and vital organs. The best he can accomplish is to wound the bear's legs and paws and hope that eventually the animal will tire of the confrontation. If he can acquire a lance, the warrior can more effectively defend himself and let the bear escape to confront him another day, or he can attack and definitively

remove the threat. Similarly, strategic aircraft range extends the NATO commander's options. Theater experts recognize "the importance of imposing delays on the movement of enemy reinforcing units westwards would be crucial to the management of the land battle in Central Europe" (29:36). The critical question is how deeply in the reinforcing structure to concentrate the effort. Tactical aircraft can take part of the task, focusing on the Pact front forces, but strategic airpower can get to the "heart" of the matter, providing distant interdiction which "has the capability of producing the most decisive outcomes affecting the whole theater" (43:70).

Hence a final reason to aggressively employ strategic airpower is to quickly disrupt the resupply effort and help the NATO commander take the initiative from the Warsaw Pact. The central theme of Soviet combat--the offense is founded on the desire to protect their country as far from the homeland as possible. This desire grows from the devastation created by invasion and counterattack across Soviet territory in the Great Patriotic War. The preplanned and structured nature of their combat is both a strength in centralized unit control and a weakness in reacting to disruptions. The Soviets acknowledge that they must maintain control of the battle to be successful. "[T]he fear of losing the initiative is present in all Soviet doctrinal activity" (24:111). One of the critical factors underlying this fear is that "without continuous logistic support the offensive must be slowed down" (24:89). As noted earlier, for the Soviets, lost speed translates directly into casualties and material losses. So "if the tempo is reduced or the timing of sequential activities are delayed, the plan is endangered and the Soviets could be placed in a position of reacting to the enemy's initiative" (24:87).

Most Soviet supplies in the Western Theater of Operations (TVD) are not stored in the forward area. Despite large overall reserves, even the most generous sources credit Soviet front line divisions with only a 3-5 day logistic supply (26:vii). If they have not been annihilated in the advance, these units depend on higher headquarters' initiatives to provide resupply. They lack sufficient organic transport to lift the daily logistic volume necessary to sustain the offensive (39:77). Exact counts vary significantly on the level of supplies advanced to the initial army and second echelon armies of the first front, but 30 days is a common figure (26:4). This is the area of principal tactical air employment. If these armies are delayed, the second echelon fronts and strategic reserve stockpiles hold the remaining 30-60 days supply in the rear areas. Hence the majority of the estimated 3 million tons of supplies and 9 million tons of FOL are reserved under central control of the TVD staff in areas on the fringes of tactical airpower (40:101). In addition, "the bulk of Soviet ground forces and their logistic support have to come from the Soviet Union, distances of some 900 kilometers [500 NM]" (12:59). Thus the USSR western military districts serve as a logistic sanctuary as well as the staging ground for the final echelon of 50 divisions of strategic reserves from the entire western USSR (40:8). This depth and volume of supply strongly suggests not only that the Soviets are prepared to fight in a prolonged conventional conflict but also that NATO should prepare alternative air attacks to counter this effort.

Keeping the supplies and men flowing to the front lines is a critical and complex activity for the Soviets. To minimize the stress on operational plans, uninterrupted supply is the responsibility of rear services and is a planning factor assumed by the forward commanders. Basic Soviet logistic doctrine states, "Considerable stress is placed on long term planning and on preparing

the plan of the rear. . . . [because] Organization of the rear and material technical supply has decisive significance for the success of the offensive" (19:57). To satisfy this doctrine, the system continually operates at the maximum levels and is very vulnerable to the unknown factors of war which Clausewitz summarized as friction. Speaking of the overall logistic problem, the 2ATAF senior army liaison officer stated, "Even if we did nothing at all to interfere with their movement, it would be a colossal problem to move such a large force up to the battle area. Air attacks. . . could cause enormous chaos" (29:29). NATO should generate intense friction by attacking all parts of this logistics system. Tactical airpower concentrates on the forward sectors of the system. If permitted, strategic airpower is the only conventional force which can attack the logistic foundation and add another layer of distress and interruption to the TVD commander's plans. Presently, within the border areas of the USSR, the Soviets can act with relative freedom because tactical air power limitations create a zone which parallels other politically generated safe havens of recent conflicts.

The sanctuaries of the Yalu in Korea and the border areas of North Vietnam substantially detracted from overall combat success (19:50), and resulted in increased friendly casualties. These no-strike zones were created because of a political decision based on fear of conflict escalation (23:59,67; 36:8). As long as NATO permits the Warsaw Pact to have sanctuaries where attack is neither feasible nor permitted, the results of forward area logistics interdiction could be equally unsatisfactory. In addition to operational limits of aircraft range, similar escalation arguments citing Soviet obsession with the protection of the "Rodina" (motherland) and potential over-reaction are used when proposing NATO limit the scope of war to eastern Europe (24:136). Such arguments reinforce the "buffer" status of the Eastern European nations and work most effectively to allow the reinforcing Soviet commanders to select the best alternative (i.e., least damaged) route to the front across Poland and Czechoslovakia.

The emphasis on second echelon attacks represents the deepest reasonable penetration of large numbers of NATO tactical air forces. Yet what can be done in the short term should not mask what should be done to defeat the enemy. Modifications to accentuate the capabilities of strategic airpower must be accompanied by the will to use it effectively. Previous Air Force leaders would not differentiate between the deep attack on targets of high national value and those of more immediate tactical interest. As one of the architects of World War II's European bomber offensives, Major General Haywood Hansell, observed "There seems little likelihood that NATO could support a major offensive on the ground until the Soviet infrastructure is substantially paralyzed" (15:3). Similarly, General Momeyer synthesized the totality of long-range war in that "the first and basic element of any interdiction campaign must be the destruction of the enemy's sources of production. The next step involves cutting the enemy's lines of supply" (23:50).

However, recommending a deep interdiction campaign in the tactical environment often evokes negative memories of recent attempts to fully "isolate the battlefield" with airpower. When defined purely as a method to totally cut off supplies to the enemy's front line forces, interdiction did not work in Italy, Korea, or Vietnam (28:32). In each of these cases, the goal was incompatible with the static or low intensity nature of the conflict. The operations in both France and Italy in 1944 show that interdiction works best when the enemy is pressed to generate maximum use of his forward supplies

(43:70), and when the goal is to restrict hostile mobility and disrupt operations (32:1).

On the other hand, strategic offensive campaigns that persuade the enemy to cease hostilities have been much more successful. For example, after World War II the US Strategic Bombing Survey (USSBS) rated the full scale Combined Bomber Offensive from October 1944 to March 1945 as a decisive element in allied victory (15:14). More recently, and in a time span more compatible with the suggested limits of European operations, the December 1972 Operation LINEBACKER II provided a relevant example for successful short-term air operations. This campaign was "a savage. . . air battle. . . . The idea was to apply extreme pressure to the very heart of the war making machine. The 11-day air interdiction campaign against North Vietnam will go down in history as a testimonial to the efficiency of air power. . . the way it should be used. . . as an instrument of national power" (2:61-2).

Beyond the operational level, the guidance of Sun Tzu provides a strategic perspective on the essence of European theater conflict. In Chapter 3 of the Art of War, Sun Tzu advised that one should first attack the enemy's strategy, then his allies, and afterwards engage his forces. Pursuing these priorities, one should attack "where he is unprepared, appearing where one is not expected" in order to unbalance the enemy's general and "force him to react to the created situation" (1:10).

The essence of Soviet military thought indicates the place which is most important to their strategy, and where the attack is least expected, is the Soviet homeland. Soviet doctrine is focused forward on the offensive to keep the enemy occupied and deny any opportunity to attack the motherland. Even so, the Soviets have also devoted considerable resources to producing a large defensive network which is formidable but not impenetrable. The Royal Air Force's DCS for Operations and Intelligence, Air Vice Marshall Walker, points out that the USSR must tailor its defenses, selecting the principal access routes and key targets for protection. "Defending the circumference of the Soviet Union against a 360 degree threat would probably be beyond the resources of even their inflated defense budget" (41:120). At the same time, non-nuclear homeland attack is unexpected because NATO has generally spoken only of limited offensive goals such as the restoration of the Inter-German Border (153) (12:32). The alliance's lack of support to Eastern Europe in 1956 (Hungary) and 1968 (Czechoslovakia) reinforces the viability and legitimacy of the buffer states as a protective factor. However, this strategy of protection and offense can be circumvented by determination, preparation, and the firepower and mobility provided by strategic conventional aircraft.

In the same fashion, the Warsaw Pact alliance lacks cohesion and is subject to significant operational problems that complicate Soviet planning. Important reservations about the combat reliability of their allies (24:118) always accompany the USSR's postulated control of all combat activities. "The Warsaw Pact remains an instrument of Soviet hegemony. . . . assum(ing) that in wartime the Northern Tier armies [of Poland, Germany, and Czechoslovakia] would be combined with Soviet forces at the army level in joint Fronts subordinated directly to the Soviet High Command [TVD]" (20:146). Yet, in the past 30 years the Soviets have strained Pact relationships by invasions or the threat of force against all their Warsaw Pact allies except Bulgaria and East Germany. One of the few reasons that Poland was not invaded in 1980-81 was its unique system of "defense of national territory" (20:145) that emphasizes the

individual heritage of that nation. The Soviets always remember the lessons of the Great Patriotic War which include Polish heroism during the German-Russian invasion of 1939.

Overall, the USSR must contend with potentially hostile and unpredictable allies. "The Czechoslovak experience demonstrated how quickly. . . national sentiments can re-emerge in an East European officer corps" (20:147). At the same time, while modernized Non-Soviet Warsaw Pact forces are not trusted to operate autonomously, "coalition warfare would evidently be difficult and create a number of vulnerabilities. The [Soviet] strategy postulates close multilateral coordination in the evident absence of integrated command and control and logistics systems and on a scale that has never been exercised" (20:148). Hence the Soviets have limited conventional options because "only a 'lightning war' strategy permits them to rely so heavily on East European military forces" while restricting the options of the East European political leadership (20:148). Aggressive operations into the Soviet homeland which disrupt the essential smooth flow of Warsaw Pact operations and prolong hostilities (12:17) can provide alternatives to the East European allies.

In summary, NATO has a serious problem of conventional defense. The primary mission of the alliance is to deter war, but the "main threat to peace is the offensive potential of the large and steadily increasing Soviet and Warsaw Pact conventional capabilities in Europe" (12:30). The 1983 European Security Study on Strengthening Conventional Deterrence in Europe concluded that the principal alternative to this growing conventional imbalance is the potential resort to nuclear retaliation rather than to allow an alliance defeat (12:32). This study recommended that NATO upgrade its defense through "new concepts and modes of operation" (12:34) designed to "enhance deterrence by creating capabilities which magnify the uncertainties in the minds of Soviet leaders as to whether their strategy will work" (12:18). The recent advent of large numbers of long range bombers offers the opportunity to carry the conventional battle directly into those areas of highest Soviet vulnerability.

Air doctrine in Air Force Manual 1-1, like its ground counterpart Field Manual 100-5 (AirLand Battle), stresses success by taking the initiative and striking deeply at critical targets before they can impact the battlefield or sustain enemy war making capabilities (37:3-2,3-3). With the flexibility and firepower offered by the extended range and payload of strategic forces, the NATO theater commander can more effectively deter Warsaw Pact aggression by quickly taking the European war directly into the Soviet homeland to hold vital high-replacement value targets at risk. At the same, he can use deep interdiction attacks to maximize delays in critical logistics, disrupt strategic third echelon reserve forces, and cause the USSR to divert further resources into homeland defense.

#### TARGET SYSTEMS

The target systems which support the twin objectives of deterrence or success in warfighting must meet several basic criteria to achieve those objectives within a credible time span. First, most of the targets in each system must be concentrated within range of the strategic forces. Second, the target systems should consist of a relatively small number of key large installations or complexes to permit rapid coverage. Third, these facilities must be vulnerable to the weapons carried and proposed for conventional attack. Finally, the targets selected should represent critical industries and logistic

links for which there are either few or no acceptable alternatives. Together, these criteria represent the optimum concentration of effort and damage potential within a given part of the national wartime economy of the USSR.

The relative value of the target systems to the Soviet leadership is highly dependent on the attack scenario. Few targets exist which would overcome or deter their plans for a deliberate conquest of Europe. But the likelihood of a planned attack is relatively low so long as the Warsaw Pact forces continue not to possess the required high correlation of forces to initiate an unprovoked offensive (30:56; 12:Part I). On the other hand, accidental or miscalculated conflict is still possible (24:Ch 2-3). Regardless of the circumstances, once committed to combat the Warsaw Pact will exploit every advantage and continue hostilities until the cost outweighs any gain. The strategic air offensive represents the quickest conventional method to increase this cost of conflict. To gain the attention of the Soviet leaders, a wide range of target types and locations must be struck rapidly and with such force that production is halted until extensive and costly repairs are completed. The prospect of years of recovery, billions of capital investment rubles turned into rubble (and the further prospect of additional billions for repairs), plus the loss of goods until full production is restored is a powerful peace incentive when compared to possibly limited ground gains in Western Europe.

Past air attacks on industrialized countries provide an important guide for measuring the scope of the effort within the Soviet Union. In 1985, General Hansell observed:

Our only experience in conventional weapon strategic air warfare against a powerful industrialized enemy was in World War II. . . . [and] extrapolation of World War II experience is dangerous. But it is the only experience we have and the basic target systems have not changed appreciably. Today, modern industrialized nations are even more dependent for their war making support and the maintenance of the economic functions of state upon great interdependent and often complex systems. . . . These target systems are still vulnerable to destruction by conventional airborne weapons accurately delivered against well selected targets. (15:4)

Unfortunately the immense size of the Soviet Union, coupled with their superpower status, and their tremendous military capability is both imposing and misleading. An analysis of open source technical literature shows that overall Soviet capabilities which developed during the post-World War II recovery period produced a series of target systems created for economic efficiency, not wartime survivability (i.e., bigger is better). In order of value to the national economy, and hence any attacking force, the four categories of most critical targets are:

1. Power Production/Transmission: The Thermal, Atomic, and Hydro production capacity concentrated in facilities of over 1000 megawatts production, and a few key transformer stations located along the highest voltage grid transmission lines inside the USSR and connecting to Eastern Europe.

2. Transportation Facilities: The important railroad marshalling yards

along the few vital double track/electrified rail lines connecting the European USSR with the front lines, plus key yards joining the industrial facilities of the Ukraine with the Urals and the central industrial areas. Additional targets are specific ports and airfields with high potential for alternative support to the Western and Southwestern TVD attacks. Bridges and pipeline compressor stations are also crucial but should be added only when precision guided ordnance becomes widely available.

3. Primary Industry: The largest and most productive iron and steel mills and coke ovens concentrated principally in the Don River Basin (Donbass) of the Ukraine. At the same time, the largest oil refineries located in the European USSR which create fuel and form the raw materials for petrochemical industries.

4. Secondary Industries and Assembly Facilities: The largest petrochemical, heavy equipment production, machine building, and repair/recovery industries in the western USSR..

NOTE: Other key systems and functions which warrant further study and prioritization when appropriate precision ordnance is available include: key highway bridges in the western military districts; communications relay centers; tactical command and control facilities; and specific small but intensely valuable industries such as automated data systems production. Additionally, only classified documents can provide appropriate specific target descriptions, exact numbers of the individual facilities, and the major armed forces targets such as Fencer and Backfire bases. Allowance for refinements in the target base due to these high priority installations must be considered in evaluating the application of force over the duration of the proposed campaign.

Each one of these target systems is currently concentrated in the European USSR, and the growth prospects project further concentration in these regions (47:Ch 7-8). To conservatively estimate the ability to cover installations within a given system, the maximum range of consideration was limited to an area west and south of the line (shown on Figure 1) that encompasses Leningrad, Kirov, Kuybyshev and continues to the Caspian Sea. The exclusion of the Kola Peninsula and the north plains areas does not eliminate any key targets. Additional important facilities (especially some of the larger plants in the Ural complex) could be covered by extraordinary means such as attacks from over the pole, or by expanding the war into the Far East with attacks from the Pacific. Such attacks would additionally serve to keep Soviet defensive forces in the Far Eastern and Central Asian districts from being diverted to the NATO confrontation. These special missions would add only a small percentage to the total target system coverage because 80% of the industry in the USSR is west of the Ural mountains (47:324).

Three vital factors shape the USSR economy. First, there is almost no surge capacity in any system. Since the mid-1930s (before the recovery drives after the Great Patriotic War), all these facilities have been working for maximum possible output to achieve the five-year plan goals. Tremendous sustained growth was demanded by the State and generally achieved by the factories (54:140-250). The cost of achieving those plans is the absence of unused capacity. The only commonly available method to increase or replace lost production is to expand into a new plant or divert production from some other part of the system (96:29; 50:95). Thus Soviet defense industries share 42% of civilian facilities so that the civilian factory can serve as

alternative production lines (91:309). Second, the rate of growth for the entire system declined dramatically in the late 1970s and early 1980s as production facilities aged and the labor force grew smaller (51:324; 54:143; 64:16). The return on capital investment reached a point where the costs of producing some items grew twice as fast as the growth in production (51:179). Finally, construction and repair takes substantially longer in the USSR than in the West because of weather, supply policies, and the bureaucracy. In the early 1980s, US/UK chemical industrialists reported that facilities which would be in operation in 18 months in Europe were still not fully producing after 4 years, in spite of the highest national priority to implement imported technology (91:211).

The following list summarizes the specific target types within each major system, their inherent vulnerabilities, and any special attack considerations. These systems are listed in a descending priority order with the sets divided into estimates of primary and secondary target requirements.

1. Electric Power (40-72 targets; i.e., 40 primary and 72 total targets). Electric power is the single most important element for an industrialized nation; its "center of gravity" (9:14). Unlike ores or other raw materials, Albert Speer, observed that electricity is either used or lost. "Power is the only resource that cannot be stockpiled" (15:14). The failure to attack the power production was the key deficiency in the Allies' bombing campaign against Germany (34:126). The chief electrical design engineer reported to the USSR that "the war would have been finished two years sooner if your bombers had concentrated on the bombing of our power plants" (15:16).

a. General System. In 1984, the USSR produced 1584 billion kilowatt hours (bn kwh) of electricity which equals about 60% of United States production (51:139,205). The system consists of an east and a west grid network (47:181; 112:--) which are not effectively joined because of the long distances between their primary generating plants (47:189).

The two grids draw on significantly different sources of power. The European regions of the USSR rely heavily on large thermal stations, a few hydroelectric facilities, and are constructing substantial atomic capacity (59:Ch 6; 47:183). On the other hand, the Central Asia and Siberian power stations are founded on massive hydroelectric dams and at-the-mine coal generating plants like Ekibastuz and Kansk-Achinsk which have capacities of 4-5 million kwh and up to 22 generators (59:196).

These latest Siberian hydro and coal projects illustrate the time required to build or recover major power facilities. Soviet hydroelectric projects take 10-15 years to complete (59:138). Similarly, after the years to finish the main buildings, the nuclear and thermal power plants take from two to five more years to install each generator and bring it up to full production and integration with the grid (58:77).

Overall the two central power grids provide 84% of the power used in the Soviet Union. An additional 14% of generated power is created by non-system combined heat and power plants which serve the largest factories, and refineries (70:58).

b. Vulnerabilities. The European grid lacks significant reserve generating capacity to cover peak load periods (58:69) or for that matter

significant losses to bomb damage. For example, the Moscow area is estimated to constantly run at 98% of capacity while the average US system uses only 62% (58:69). The lack of available reserve power causes frequent losses in some areas as resources are shifted between consumers. In 1984, Gorky oblast reported over 3000 outages (51:204). To compensate for these shortfalls, the USSR has spent 15 years (with little progress), trying to develop 1100 to 1500 kilovolt long transmission lines to transfer the abundant Siberian power reserves (47:109). Another vulnerability is the lack of redundant transfer links between the regions of the western Soviet Union. Only two high tension lines join the Baltic with the Ukraine, and a single link connects Moscow to Leningrad (59:196; 112:--). At the same time, the Soviets connect their energy production in the Ukraine to the East European "Mir" (friendship) power network with a single 750 kv link at Uzhgorod near Czechoslovakia (112:--; 59:196).

A third critical problem for the Soviets is system control and responsiveness during a crisis. Monitoring instruments are unacceptably poor (91:225) but problems develop at a speed (as little as one half second) which demands an automated control system to maintain plant output from the multiple generators (a system termed analogous to automotive cruise control) (66:3). Finally, many European USSR powerplants were converted from coal to oil and natural gas to ease the burden on the railroads. The volume of coal used as fuel dropped from 66% to 22% over the 1965-75 period (47:164). Therefore these facilities are now critically dependent on the few major pipelines from the Caucasus and Siberia (112:--; 47:170).

The most important vulnerability for an attacker is any power system's inherent sensitivity to blast and fragment damage. The US3BS found that one or two random collateral hits were sufficient to knock out or significantly reduce power output during wartime for six months to one year (35:126). This sensitivity comes from the high precision demanded by the machinery. For example, large generators can take eight hours spinning up to full speed or stopping (58:85), and their turbines operate 600-degree water at 1810 psi (59:163). Similarly, most transformers require oil immersion to function properly (63:3). Puncture the case and this vital cooling oil is lost.

c. Targets. In the western USSR the primary targets are the 30 thermal, 3 hydro, and 7 atomic power plants whose individual production capacity exceeds 1000 megawatts each (112:--; 59:190). Simultaneously, 8 key transformer stations in the grid should be destroyed. The secondary targets in this region are the 22 additional power plants which have 300-1000 megawatts capacity (112:--). The importance of the power industry warrants attacking all 32 targets as a first priority. Together they comprise over 57% of total Soviet generating capacity, and 83% of the capacity west of the Urals (70:54). Attacking the power system has an immediate effect on logistics transfer, the production capacity of the war sustaining industrial base, and represents the first warning to the Soviet leadership of the cost of continuing the attack.

d. Impact of Atomic Power Station Attacks. The Soviet Union has 14 operational nuclear generating stations with 41 reactors either on-line or under construction (67:14). Nine of these facilities are in the European USSR (47:186). As a high value target, Atomic power plants represent some of the most expensive construction in the world. Each plant costs \$2-4 billion (or roughly \$1 billion per reactor) to build and requires years to complete (67:19; 60:37). The USSR is increasing the importance of nuclear power as a part of the total energy program (100:358). Premier Ryzhkov announced to the

1986 Party Congress that by 1990 these facilities would generate 20% of Soviet power needs, about twice their present contribution (52:81).

Atomic power plants pose a special attack problem in wartime which international conventions have incorporated into the Laws of Armed Conflict. The primary concern is that, like dams, these facilities represent the possible release of uncontrolled and indiscriminate massive force. In 1977, an additional protocol (Article 56) was added to the 1949 Geneva Conventions to specify the prohibitions and conditions for attacking these targets (67:112-120). The protocol permits attacks only when the power output directly serves key military facilities involved in the war effort (67:119). During an all-out NATO-Pact confrontation, as a major sector of the western power grid, these nuclear generating stations meet the support criteria. They will provide power to national command and control elements, active forces staging from homeland bases, mobilizing reserve units, the electric railroads moving supplies, and the structure of Soviet industry supporting the war effort.

Direct attacks on some of the stations could damage the controls and circulating system needed to prevent nuclear accidents. The older light graphite moderated reactors (LGMR) such as Chernobyl do not provide the intense protection of the double reinforced-concrete containment structures associated with the pressurized water reactors (PWR). The transformer yards at these facilities are effective alternate airmports to eliminate power output if no release of nuclear material is desired. However, simply prohibiting attacks on these facilities will not guarantee the absence of a crisis as power is depleted in the rest of the system. After all, the Chernobyl disaster was the result of improperly testing for the real wartime possibility that both the system power and the back-up generators needed to circulate cooling water will fail (60:34).

In Destruction of Nuclear Facilities in Wartime, Dr. Ramberg suggests in addition to cost and lost power production other reasons to consider attacks on nuclear plants (67:xi). First, the cost of a nuclear accident clean up is enormous. TASS reported via the Associated Press in February 1986 that the bill for the Chernobyl incident is now estimated at 14 billion rubles. Second, these serious disasters can divert hostile resources, critical manpower, and the attention of the leadership from the war effort, especially if the attack is perceived as an accidental outgrowth of a purely conventional conflict. Plus the disruption in the area around the plant can negate the support provided to the war by local military facilities, and hinder troop movement through the downwind area (67:23). Finally, holding Soviet and other Pact reactors directly at risk provides a counter threat for the safety of West German nuclear power stations located in the forward battle area.

2. Transportation Systems (39-109 targets) "The lines of communication are essential lifelines for Soviet forces" (12:64). Within these LOCs, the railroad is the essential transport system of the Soviet Union. Despite extensive government campaigns to reduce the load, the railroads still carry 80% of the traffic (70:200). In 1980 the rail system moved 3,910 million tons of freight a total of 3,641 billion ton kilometers (51:321). Compared with the US, the USSR has half the track mileage and carries 60% more freight (derived from 78:-- , 51:--). Other forms of movement such as roads, air transport, pipelines, and waterways each have specific specialized uses, but the heart of the system is the electrified dual track railways connecting the principal industrial centers of the country. Two-thirds of the entire rail

system load is carried by these links which comprise only 30 % of the system (94:29). In short, certain sections of the USSR railroads are the most heavily used lines in the world (70:201).

a. Rail System (30-80 targets).

1.) General. The Soviets operate a modern rail system which is the equal of any network in the world. The main components of this rail system are the equipment, tracks and facilities, and the operating environment. The primary engines are modern electric traction and diesel locomotives which the system adds at the rate of 400 electric and 1200 diesels units per year (52:83). At the same time the Soviets produce 72,000 railcars each year (94:53). The traffic density, system size and heavy emphasis on maximum usage (51:321-324; 47:307-312; 77:--; 88:--) indicates that the overall Soviet system approximates the 25,000 locomotives and 1.2 million cars found in the US system (79:541-591). Most of these cars are open top bulk carriers, flat cars, and boxcars (88:120) because the principal cargoes remain coal, ore, construction materials, timber, and grain (70:200). Specialized vehicle transport and container handling units (which would be of most use to the military) are not widely available but are 30% of current priority railcar production (78:509).

The location and density of tracks reflects the Soviet emphasis on heavy industry support. Figures 2 and 3 show the principal rail lines in the western USSR (111:--). The major concentrations of critical electric track are in the Ukraine, serving the Krivoy Rog iron fields, the Don Basin coal fields, and the numerous heavy industries associated with the USSR's largest concentration of iron and steel plants. From the Ukraine principal lines run north to the central industrial areas. In contrast, the Baltic and Belorussian areas have very few heavy rail lines. Similarly the support facilities along these lines reflect modern improvements such as automatic block signalling and automatic switching in most of the classification yards (78:529).

In comparison, Soviet operating procedures are unique. Railroads in the USSR have operated on a "war-time" surge footing since the 1930s to produce maximum output within a slowly growing system (76:129). To meet their plan goals, the railroad system developed a unique series of specifications which asserts their dominance over almost all industrial sectors (84:Ch 4). Unlike their US counterparts, the Soviet railroads have developed a complete system of customer service which allows them to dictate the loading/unloading schedules of trains. Cars sit in the marshalling yards until the rail dispatcher decides sufficient cargo is destined for one direction to warrant creating a train (88:106).

The Soviets have the world's longest average overall distance travelled per load, almost 1400 kilometers (77:76), but still move goods at a fairly rapid pace. On average, each freight car will be loaded every 5.5 days (85:38). In comparison, during the same period the French took 8 days and the British 10 (88:111). This turnaround time for freight cars is achieved at the expense of the customer. Locomotives switch trains every 300 km and the average car travels less than 450 km per day (70:201), but when it arrives, the customer may have less than 24 hours to unload and reload the car (88:106). Overall, 40% of turnaround time is spent in the various marshalling and classification yards on the way to the destination.

2.) Vulnerabilities. The western USSR sectors of the rail system have very few natural chokepoints or obstacles. With precision ordnance, the long Dnepr, Dnests, and Volga bridges would offer critical points. The last time these bridges were destroyed, the Russians took two years to rebuild them (73:5). Otherwise, the biggest natural hazard to train movement is the winter weather when frozen cargoes can increase manual unloading by 50 times (51:223). The most important vulnerabilities are man-made and have resulted from the emphasis on maximum use of the electric rail lines.

First, beyond the catenary (overhead wires), the electric tracks differ from the nearby secondary track in very important details. The electric trains pull the greatest loads (up to 4000 tons per train) and require the heaviest rails (75 kg per meter (150 lb/yd) or R75) (84:8). The adjacent secondary route are generally constructed of lighter R65 or R50 rails and can't carry the same weight without extensive maintenance or track failure (84:171). Transferring to the non-electric route not only means changing to diesel traction locomotives, but also reforming the trains into smaller units (like the average European train which is about 1000 tons) (8:72).

Second, the double track electric lines lack redundancy. There is only one complete line to Poland and one to Czechoslovakia (Figure 2). The partially electrified link from Leningrad to Vilnius intersects the only electrified double-track lateral line connecting Kaliningrad on the Baltic with Minsk, Kiev, and Odessa on the Black Sea. Hence, the figures show that most of the alternative routes are single track non-electrified lines.

Third, any traffic moving between the Warsaw Pact and the USSR is delayed because the rail gauges aren't the same. Cargo and passengers are either reloaded onto another set of cars; or specialized cranes and jacks are used to lift the cars and replace their wheel bogeys. With the skilled personnel this process, this requires 10-15 minutes per car (88:9). Furthermore the number of transloading facilities is small. Along the entire border there are 15 transloading areas, only 10 of which join the USSR with Poland. These transloading areas are significant chokepoints, and so are the Soviet marshalling yards where the lines serving these areas intersect. For example, L'vov, Baranovich and Vilnius are critical junctures for traffic in the western military districts.

Finally, the reliance on electric traction for the high percentage of heavy traffic makes the system very vulnerable to the power grid attack. The Soviet rail system draws power directly from the regional grid and has no secondary source of electricity (8:41). Loss of power means that yards, sidings, and main lines will have to be cleared by diesel locomotive, a slow process because the automatic signaling equipment will be inoperative (88:15).

3.) Targets. The key rail targets are the 15 known transloading yards and 15 additional classification yards along the double track electric system which feed support directly into the TVDs (Figure 2). Secondary targets are 15 yards further from the border at intersections where multiple track traffic could be transferred to the less capable single track sections. This layered approach degrades the logistics handling by creating more damaged facilities for the enemy to work around or repair (7:200). In addition, there are 15 railroad targets supporting the strategic industrial attack (Figure 2). These installations will disrupt main railyards linking the Ukraine with the central industrial area and the Trans-Siberian Railroad.

Special Note on Logistics Volume Estimates: The important variables in the transportation network are significantly influenced by the volume of wartime traffic the system is expected to provide the fronts. For a system that moves 3900 million tons annually in peacetime, the need for 12-20 million more (including stockpile replenishment) in wartime may appear to be an insignificant increase. However, most of the experience in large scale transfers of material is on other lines outside the Belorussian and Baltic areas (47:344-347). Plus these routes handle high volume materials (coal and ore) which are substantially different from military cargoes such as ammunition and spare equipment. In addition, as previously noted, the few high capacity electric rail links serving the strategic stockpiles of the TVD also have to provide transport for strategic reserves and replacements.

Estimating the increased daily requirement to move and unload cars is a more illustrative method to show the level of logistics complexity and effort on both sides of the transloading zones. A supply flow into Poland, Germany, and Czechoslovakia of approximately 150,000 tons per day for offensive use and replenishment is consistent with estimates of both TVD reserves, and the offensive rates of use for first echelon fronts (39:79; 12:75). Depending on the ratio of liquid POL to solid cargo like ammunition and equipment (which takes more space per ton), 6000 to 7500 cars are needed to carry one day's tonnage.

In more concise terms, that's 120 to 150 trains traveling in one direction each day, with an equal number returning via a parallel track. In addition to the 300 trains, other cars are needed to sustain a complete daily "pipeline". Considering the time spent in loading/unloading operations, the changeover delays in the transloading areas, and the distance traveled to the front and second echelon areas (i.e., the military equivalent of turnaround time), the total fleet would approach five times the daily requirement, or approximately 30-38 thousand cars on the European standard gauge lines. The volume on the USSR broad gauge side would be equal or greater depending on the shifts in reserve forces and the level of western military district stockpile replenishment. Overall, the Soviets may need 75,000 cars dedicated to the rear area effort.

If the USSR is unhindered, and the war is short and proceeding as planned, most estimates project the Soviet Union can handle this additional traffic volume (76:101). However, there may be considerable problems on the East European side because the Polish system is already short of rail capacity to meet its own peacetime requirements (73:476).

b. Alternative Transportation Systems. Analysis shows all other forms of transport in the USSR have some serious seasonal variation in productivity or some inherent flaw which makes them at best secondary war supporting systems.

1) Road Transportation. Roads are the principal short haul system of the USSR. Trucks deliver over 80% of all goods, but the average distance traveled has been less than 20 km for the last 15 years (77:80). The Soviet's now produce 700,000 trucks each year (150,000 at one plant) and are placing greater emphasis on road alternatives (47:47). However, in the world's largest nation, the quantity of good roads is very low. There are less than 500,000 km of paved road in comparison to 6 million km in the US (94:53). This lack of highways still precludes development of any comparable state industry equivalent to American long-haul trucking.

Even though the Belorussian and Ukraine (Carpathian military district) areas have the highest density of 2-lane hard surface roads (94:31; 47:300), a critical vulnerability of the system is the low weight capacity of the bridges (8:25). This deficiency is compounded by the small number of lateral highway connections across the Pripyat marshes, and the few (10) major highway crossing areas from USSR to eastern Europe (47:300). In addition, the spring and autumn rains traditionally discourage use of any non-improved surface road for heavy military traffic (98:74). Using the secondary roads, cuts military traffic speed by 35-45%, raises fuel consumption 20-40%, and increases maintenance 40-50% (76:96). Disruption of the railroads could add an additional burden to these few paved highways. In the future, destruction of significant highway bridges with precision ordnance could force diversion of engineer assets to sustain movement and resupply.

2) Airlift (2-12 targets). Soviet military transport aviation (VTA) consists of 585 (40:70) short and long range aircraft which can be supplemented by 200 additional transports and 1200 passenger aircraft from Aeroflot (40:83). If all the Aeroflot transports and 75% of the entire VTA moved cargo into the Pact countries, their total lift would be only 19,000 measurement tons per mission (40:99). Three missions each day might provide 25% of the sustaining logistics required, but the bulk nature of POL and ammunition precludes efficient air transport. In addition, the air logistic port handling systems are important bottlenecks in this system (8:66). Leningrad and Kiev have the largest Aeroflot facilities to provide support to VTA (47:408). Likewise, the regional airports at Riga and Minsk could be used by AN-12 CUB transports as could 8 other regional civil airfields in the western military districts (47:408). Extensive Aeroflot use would be limited by the handling and ramp loading capacities (95:32). In the absence of specific aircraft concentrations and evidence of civil reserve air operating locations, the recommended targets are confined to these government fields in the European USSR, but military transport fields should be from classified sources.

3) Sealift (7-16 targets): The Soviets have invested significantly to acquire the most modern sealift technology in order to make their fleets competitive on the profitable Atlantic and Pacific commercial routes (101:573). Most of their new ships are specialized vessels like container ships, roll-on/roll-off (RO-RO), and LASH (barge) carriers (51:326; 89:709). Although designed to acquire hard currency, the fleet also possesses a credible military lift capability if the ships can be gathered into home ports. In the Baltic, the key ports of Rostock in East Germany and Szczecin (Stettin) in Poland are tied to critical land transport nets and are close to the front (112:--; 106:--). At the same time Gdansk and Gdynia in Poland are only 100 NM by sea from the important Soviet ports of Kaliningrad and Klaipeda. The USSR already operates three 100-car train ferries to Rostock daily (the equivalent of 7-8% of the wartime forward requirement) (51:322).

There are seven principal USSR ports on the Baltic (46:318) but their functions vary significantly. For example, Ventspils is the terminus for a Siberian oil pipeline (112:--), while Leningrad is recognized for naval shipbuilding and commercial activity (47:318). At the same time, Liepaja and Riga are the primary centers for container handling, the newest and fastest growing sector of maritime transport (89:75). The volume and quick turn around advantages of rail and sea containers were readily incorporated into the Soviet transport economy (51:313; 78:320).

Containers are a new factor in Soviet military operations. While the heavy containers prevent pilferage in peacetime, a major civilian problem (51:322), they also deflect all but the most substantial bomb fragments during a war. Major container facilities are characterized by their dependence on one or two very heavy cranes for loading operations, speedy cargo transfer, and an almost mandatory requirement for automated inventory control to keep track of storage areas that generally exceed dozens of acres and thousands of similar container (89:311). These two vulnerable points are best struck with precision ordnance, but multiple accurate weapons deliveries can also cause significant disruption.

On the other hand, the traditional port facilities of the USSR are notoriously slow in unloading and processing cargo (88:126). In addition, the Baltic ports are further limited by ice in the winter. The advent of good freezing weather for solid secondary roads is the beginning of diminished maritime support. Likewise the "warmer" ports of the Black Sea are plagued by winter weather constraints. The nine principal ports generally concentrate on shipbuilding and the transfer of bulk cargos like ore and oil (47:118). However, their facilities are large, complex, and could support the logistic needs of the Southwest TVD against NATO's southern flank.

Just as Allied sea transports provide massive NATO reinforcement, by volume, Pact sealift has the largest capacity to bring USSR reserves and logistics to the front area. Handling these cargos is the biggest limitation of current Soviet facilities. Soviet ports grew 40% from 1965 to 1990 while the demand for processing cargo grew 80% (51:326). Therefore, depending on the season of the attack, the primary targets are the Baltic ports, with the Black sea ports struck as secondary targets.

4) Inland Waterways. Even with large scale government incentives, the Soviets cannot get their plant managers to ship cargo by river and canal (76:14). The system is too seasonal (98:258). When the water isn't too low, too high, or ice, the deliveries are haphazard and too slow for any cargo more critical than pulpwood (79:18). Locks and pump stations are good precision targets but should not be selected until there is clear evidence that the military logistic net is using specific facilities.

5) Pipelines. Natural gas and crude oil pipelines are the most significant non-rail sector of the transportation economy. The system of 48- and 56-inch lines bring Siberian fuel from the Tyumen fields and Central Asian oil from Karaganda to the industries, power plants and military consumers of the western Soviet Union (112:--). More importantly, the Eastern European countries are becoming increasingly dependent on USSR natural gas for their consumer and industrial needs. All Warsaw Pact countries except Romania get 75-93% of their imported fuels from the Soviet Union. These imports range from 20% (Poland) to 75% (Bulgaria) of each countries total energy needs (100:660).

The gas pipeline net resembles an 'H'. On one side gas flows into the Ukraine through Kiev to Uzhgorod (the same location of the Mir power link to the Pact allies) and then to central Europe. On the other side, the line runs north of Moscow thru Minsk to Poland. There are only two crosslinks in this system, the first near the Polish border, and the next from Bransk to the Moscow area (47:127). Crude oil distribution is even more simplified and vulnerable. A single pipeline runs from Kuybyshev to Bransk and then splits: one branch to the terminal at Ventspils, the other through the Mozyr refinery

to both Brest (Poland) and Lvov (Hungary) (112:--).

These energy lifelines were built principally from imported West European pipe because Russian pipe is too flawed (100:404; 51:208) and are mostly powered by imported compressor stations (100:370). Russian maintenance keeps only about 50% of any pumps at these facilities in working order at any one time (64:78). Nevertheless, the Soviets continue to place great emphasis on pipeline branch expansion to further reduce railroad transfer of coal and to overcome the inability to move electricity into the European industrial area from Siberia. Alongside the primary pipelines, as many as four additional lines may parallel the first to provide large volumes of fuel to key areas (46:177). While these pipelines are a crucial link in the Soviet industrial "web", the natural internal strength of the system (sustaining operating pressures in excess of 1100 psi) (47:178) requires the accuracy of precision munitions (PGMs) for high confidence attacks. As soon as multiple PGMs can be carried on conventional strategic aircraft, three to five pumpstations located along each major route and at vital junction points should be added to the primary target list. The extended use of foreign materials and the Soviet maintenance record on these important fuel transport systems suggests that damaged stations and pipelines will not easily be replaced during a NATO conflict.

3. Primary Industry (36-56 targets). Placing basic industries like iron, steel and oil refining ahead of war production and final assembly plants is strategically valid for the same two reasons that the Germans considered vital in World War II: target system concentration and cost of replacement (34:109). In the short war scenario, whether steel mills or tank factories are the first targets struck, there is little chance that their disruption will significantly affect the tactical situation. Instead, reducing the steel mill offers the opportunity to degrade a variety of other factory's production as the long term effect ripples through the economic system until the mill fully recovers. In addition, restoring large complex units like blast furnaces may take substantially longer than repairing an assembly building where the principal components may simply be temporarily diverted elsewhere for construction.

a. General. Two previously targeted fundamental systems, power and rail transport will also start the erosion of the industrial base. In the worst case for the attacking force, the largest and most important of Soviet industrial facilities have raw materials stockpiles and their own power plants (as part of the 14% independent heat and power installations). These facilities must be directly attacked to reduce their effectiveness. The number of targets to strike should represent either 50 or 70% of national capacity. In an industrial economy, the loss of 70% capacity in one industry reduces its contribution to the level of severe austerity. At the same time, the system is economically non-productive if 50% is destroyed (49:6).

b. Vulnerabilities. Both the oil and steel industries concentrate production in a few key facilities which are further grouped into a few regions. In the future, there will be even further concentration back into the populated western USSR because it's now cheaper to ship the energy into the plant than it is to ship both the raw materials and the finished products over long distances into Siberia or Central Asia (47:210).

The basic industries produce their material by a series of steps. The raw

materials are turned in intermediate products like pig iron which are the passed to the final production process such as the steel furnaces. The output materials can then either be shipped elsewhere or transformed on site into finished products in rolling and blooming mills. Thus, the entire facility does not have to be leveled to terminate the primary function. The USSR estimated that a fractional coverage of 25-30% is generally enough to shut down these plants (34:91).

c. Oil Refineries (20-30 targets). The oil industry is concentrated in 41 refineries which can process 94% (or 567 million tons) of Soviet crude oil production (70:180; 112:--). Overall, 20 of the 26 largest facilities, and 10 of 15 smaller plants are within range. Approximately 72% of Soviet refining capacity can be covered by attacks on these 30 targets. Although most oil refineries are large and complex targets, the smaller central catalytic cracking area is the critical element. Eliminating the ability to reduce crude oil into its components eliminates the function of the refinery.

d. Iron and Steel (16-26 targets). In 1981, 26 large plants with 1 million tons or greater output produced 90% of the USSR's 148 million tons of steel (70:96). Nine of the 15 very largest Soviet Iron and Steel plants are in the western USSR. With the exception of Cherepovets and Lipetsk, all these large facilities are further concentrated in the Donbass (112:--; 47:209). Several Ukrainian plants like Krivoy Rog and the two Zhadanov plants now rival Magnitogorsk in achieving the highest annual production. The mills are central elements of the Soviet economy and represent a vital investment of both labor and capital. "A large iron and steel mill takes 7 to 10 years to bring into full production and should employ 20,000 people. This consumes the work force of a town of 100,000. . . Magnitogorsk [the old cornerstone of the iron industry] employs 70,000" (47:207).

In addition there are other critical elements in this industry. Most of the iron and steel mills in the Ukraine, the Volga, and the Moscow industrial areas depend on a single coke production facility at Krivoy Rog. This set of ovens has 50% of the national production; 10 times the volume of the next size facility (100:493). Equally important is the Zaporozh'ye manganese processing facility which supplies the entire region with this critical steel alloy element (94:Ch 9).

The primary set of 16 targets consists of these two plants plus the nine large iron and steel mills and five smaller multi-million ton installations. The secondary targets add the remaining 10 plants within the area which produce only steel (47:208; 112:--; 70:Ch 7). These secondary targets are of lesser value because they are more dependent on the transportation network to supply the pig iron to the factory. Overall, attacks on these targets will cover 80% of iron and steel facilities.

Furthermore, there is a synergism to the strategic offensive which accentuates confusion and further decreases enemy effectiveness. Once NATO initiates air attacks, the threat of air raid is almost equally as effective as the actual devastation. German records indicate that for 1943 and 1944 at least 20-25% of lost steel ingot production resulted from air raid alerts which were not followed by an attack (35:78).

4. Secondary Industry (139-213 targets). Once the basic industries, transportation, and power networks are struck, the attack can expand into

additional high value facilities. These industries mostly show the same heavy concentration in the western USSR as the basic facilities (47:221) because they are located as close as possible to the source of raw materials (i.e., the refinery or steel mill). For example 96% of diesel locomotives are produced at the Voroshilovgrad plant and most electric engines are manufactured at the Novocherkassk facility (70:204). Both are located close to the Donbass steel mills. Other industries, like electric motors and machine tool manufacturing, are dispersed throughout the target search area. In general, the selected facilities are of high value and also produce repair or replacement components for the recovery effort. At the same time, degradation of the petrochemical and heavy equipment sectors has an additional impact on other economic sectors like the construction industry and co-located armaments production facilities.

Overall, the secondary industry targets represent the expansion of the attack into more complex and interlocking economic sectors. Once again successful power and transportation attacks offer an opportunity to degrade these systems before directly attacking them. For example, the loss of power would be dramatic since 97% of all industrial machines are electrified (50:97). Additionally, the Gorky automotive assembly plant is a clear example of transportation dependence as it receives components from 35 different factories up to 1400 km distant (47:213). For the secondary industrial targets type, Table I shows the percentage of the national system which can be covered

INDUSTRY	TARGETS		TOTAL
	PRIMARY	SECONDARY	
PRIORITY ONE			
1. POWER PRODUCTION	50	22	72
2. TRANSPORTATION	39	70	109
3. PRIMARY INDUSTRIES			
Iron & Steel Production (60%)	16	10	
Oil Refining (70%)	20	10	56
PRIORITY TWO			
4A. SECONDARY INDUSTRIES			
Heavy Equipment Production (53%)	26		
Railroad Equipment Repair (57%)	16		
Petrochemicals (69%)	25	8	
PRIORITY THREE			
4B. SECONDARY INDUSTRIES			
Power Machinery Equipment (71%)	42		
Electrical Equipment (66%)	10		
Cement Production (54%)	20	15	
Machine Tools Equipment (74%)		35	
Motor Vehicle			
Production (84%)		16	213
TOTALS	315	135	450

TABLE I. TARGET RECOMMENDATIONS

Therefore, the final proposed target structure for the initial missions into the USSR is shown as Table I. The size of the list permits flexibility in selecting the attack sequence within each system to optimize operational considerations like deception and surprise. The complete power system should be the first priority along with primary transportation and industry. The second attack priority should complete the basic industry targets and expand the attack into additional high value areas. The final stage of the campaign would center on recovery and reconstitution industries.

#### FORCE EMPLOYMENT

Even though NATO's goal is to deter aggression, the strategic forces must be able to carry out the campaign if that deterrence fails. Three essential concepts limit the effects of strategic conventional bombardment: individual aircraft target lethality, enemy recuperability, and bomber survivability. Force employment evaluates the general sortie requirements to "knock out" the targets developed in this target analysis and projects total mission requirements based on a range of attrition forecasts.

The relatively small and finite number of bombers and the multi-million dollar cost of fielding new systems led the noted author Herman S. Wolf to close his 1981 History of Strategic Bombing with the projection that "... the future of the Strategic bomber is uncertain. What is certain is that there will not be another war like World War II. The great bomber armadas will not go forth by the hundreds and thousands to strike strategic objectives" (45:83). Critics of strategic bombing may see a lack of numbers as equalling a lack of capability. While the return of the conventional strategic bomber force cannot provide the same quantity of aircraft, it can provide equivalent combat power in bringing destruction to an enemy.

The goal of any air attack is to render the target useless (11:45). However, total devastation usually requires an extremely large number of sorties. The industrial damage evaluations gathered by the US Strategic Bombing survey show that significant capabilities are generally lost when 25-30% of the contents of a factory are destroyed (34:91). Twenty-five percent damage to the contents was usually achieved when the external sections of the building had 40% visible structural damage (34:92). Using 40% targeted coverage as the criterion for successful degradation, the actual damage effectiveness of general purpose weapons reveals a significant relationship between principal strategic bombers.

Overall, Table II (Appendix A) indicates a B-52 equals the combat strength of about 20 B-17s across a spectrum of target dimensions. Thus the force of 150 B-52s represents approximately the same combat power as the 3000 B-17 aircraft in Eighth Air Force and Fifteenth Air Force in 1944. This substantial increase in effectiveness is the product of improved accuracy and much heavier payload. Based on increased survivability, Gen Hansell estimates an even greater relative power for the B-1/B-2 (a ratio of 125:1) (15:19).

For the identified targets, each power station needs just two bombers to eliminate the average transformer yard and provide much more than the random collateral damage cited by the USSR as requiring 6-12 months to repair. At the same time, the wide variations in overall rail and industrial facility dimensions can be standardized by focusing the attack on their most critical components. Then, as a planning factor, an average sortie requirement per

installation permits force projection with the necessary variation in the actual attack to account for the oversize and small facilities. For 40% coverage, six bomber sorties can attack the most vital 1000 by 4000 foot section of any industrial or rail facility. This attack would cover about 1.6 million square feet of the installation with significant blast effects. Their direct damage would be further increased by post-attack fires which are wartime industry's biggest threat (103:34).

As indicated by several of the previous target examples, many Soviet facilities are exceptionally large (to the point of being the largest in the world) (51:--; 47:--). Covering these gigantic factories and mills demands more than six B-52 sorties. So, these targets are primary candidates for the extended coverage produced by the 84 weapons of the B-1. In total, the priority one targets need about 600 sorties for complete coverage, and 1530 will cover the entire 312 primary and secondary target set. The expanded attack requires another 800 sorties for the last 138 targets.

After the initial attack, one of the most intense clashes of wartime "willpower" is that of the strike planner working against the rebuilding effort of the repair crew. In the past, only persistence on either's part yielded success. As one veteran of Korean interdiction reported, "Imagination and tenacity on the part of the enemy have proven difficult to beat" (21:189). In industries where damage is common, as with railroad trackage, knowing the capability of a good mechanized repair team is an important factor in correctly prioritizing targets. For example, the ability of a Soviet crew to re-lay and re-ballast two miles of track in less than nine hours (22:57) makes track cuts wasteful and unattractive. On the other hand, the scarce expertise and unique recuperation equipment can become important targets to degrade enemy recovery. More importantly, the complexity of the damaged target system can work to the disadvantage of the recovery force (2:50).

The initial goal of a strategic air campaign must be to wage an intense offensive like LINEBACKER II which presents the enemy with more destroyed facilities than he is prepared to recover. In fact the decision whether to invest resources and repair a given facility is often a function of the enemy's perceived damage to the whole system (49:72). Estimating the USSR's capacity for recovery is a product of their World War II experience and current construction performance, combined with the unknown varying levels of damage to each installation achieved in actual combat. A key limitation is the absence of information concerning the capacity of any present system to recover multiple diverse installations simultaneously over a large geographic area. The only data available is for single facilities in disasters or old information on entire nations (i.e., post war Japan, Germany or Russia).

Table III (Appendix A) provides estimates of construction of single new facilities in critical industries based on data used by US Civil Defense authorities. Three factors suggest that these US estimates (which range from 3 months to almost 3 years) would be optimistic for the USSR. First, the damage has to be removed from the site, and past Soviet experience with climate and competing economic demands indicates slow construction performance below western averages. Second, there are hidden delays like individual long lead time items which compound the recovery calculation. For example, "German WWII [sic] experience in refinery repair indicated that pressure vessels and valves were the most difficult to obtain. Pressure vessels in the petroleum refining industry are custom built items" (59:66-67). Third, even when the facility is

repaired, the Soviet steel mills and power plants experience shows that significant additional delays occur when bringing the facility back on line. Overall, Table III illustrates just how long major recovery efforts can take to rebuild a single factory not an entire system. Hence when faced with a credible strategic NATO offensive, the Soviet leaders would have to weigh the advantages of a two-three week NATO war against the average two to five year homeland recuperation. In addition, the total loss of major installations like nuclear power station and hydro facilities and steel mills could take 10-20 years to restore.

The timing of the strategic attack is critical and should happen as early as possible in the war to compound the recovery problem. The rapid success achieved by both the Germans and British in developing simple, cheap, and relatively effective cinder block and sandbag blast walls (to protect machinery in factories and power plant generators (103:15-21) is a major factor supporting early attacks on the priority one and two targets. The Soviets are widely regarded in the industrial community as hopeless bureaucrats, but they could copy the German protective measures. Several engineers engaged in joint ventures commented how efficiently the system could mobilize masses of students and workers to solve a problem where labor shortage was the key (97:599).

In addition, to maximize the enemy's perceived impact of NATO interdiction on offensive operations, the air attack should synchronize with the enemy's ground campaign attacking while the Soviets are on the offense and using large volumes of supplies. Far East Air Forces in Korea reported, "the best time for an interdiction campaign is when the ground situation is fluid, the fighting intense, and the enemy's logistic needs the greatest" (19:23). This view is reinforced by other analysts who concluded, "the opening phase of the campaign should utilize surprise and be as massive as possible. . . a slow build up can prove more disastrous than no campaign at all" (6:22). Of course the best view of how to fight the Soviet Union is provided by one of their key strategists, Col. V. Yet. Savkin, "only by a decisive offensive conducted at a high tempo and to a great depth is defeat of an enemy achieved."

Risk in a conventional war is a relative term. Casualties will happen, but the quantity is uncertain. "Survivability among the Warsaw Pact defenses is the key to a successful interdiction campaign" (19:48). Strategic airpower can deliver critical strikes at great depth early in the conflict. "Can the force survive long enough to sustain the attack over the 15-20 day duration of the short-war concept? The air defense in the USSR represents a pattern of contrasts suggesting that the manned penetrator in a conventional war can be an effective weapon system if properly modified for self-protection. On the one hand, the USSR defends a huge land area with 2250 fighters including some of the latest fourth generation look-down shoot-down aircraft but also with some of the oldest aircraft in the inventory. The surface to air missile systems, encompassing almost 9000 fixed SAM sites, have the latest SA-10 for point defense, and still continue to operate the old SA-2 in some areas. While the active duty defense forces of 400,000 are augmented by over 960,000 reserves in a crisis, the budget doesn't match the dedication of manpower. Air Defense forces operate on a constrained budget that is half the size of the Soviet Air Force and smaller than any other force except Strategic Rocket units (10:96-98; 40:Ch 3-5; 51:Ch 6). In short, the Soviets cannot afford to be in all places at once, and they have vulnerabilities that can be exploited by surprise and unpredictability. For example, the European Security Study on conventional defense reported "Fact air defenses. . . are ineffective to date against

aircraft flying low and fast." (12:181)

Estimating the impact these forces could have in a conventional conflict is a risky business especially when "the determination of (detection and kill probabilities) are themselves largely based on assumptions" (28:9). The lesson of real wars is that offensive aircraft usually survive much more effectively than the estimates project: "real wars continue to confuse the issue with real loss rates considerably less than those theoretical predicted" (41:119). Air Vice Marshall Walker found a constant 1% attrition in loss rates for World War II, Korea, and the 1973 Mid-East war (with Vietnam ten times less) (41:119). He further concluded that rates approaching 10% significantly degraded the long term capability of a tactical force (41:120). Figures 4 and 5 (Appendix A) present the 15 mission cumulative sortie outlook for strategic forces using 1% and 10% projected attrition. Even at 10% the B-52's can cover the Priority 1 targets in six missions.

Based on the finite numbers of available B-52 airframes, one per cent may be historically accurate but overly optimistic to use as a planning factor. Therefore, as a more "realistic" example, Figure 6 depicts cumulative sorties within a variety of strategic conventional and dual-role force employment possibilities. These computations project sorties based on a 4% attrition rate for the B-52/FB-111, and a 2% rate for the advanced bombers, with an 8% operationally ready rate for the first 10 missions (70% for the last 5). This provides an estimate for an air defense environment forty times more hostile than Vietnam. At this rate, the 150 aircraft force is able to cover the primary air campaign targets with additional sorties available for ground support and a deep offensive air campaign. Adding dual-role aircraft will draw down portions of the nuclear warplan commitment, but offer the opportunity to cover both the primary and secondary targets at least once within the first 10 missions.

In either case, to reduce the uncertainty and risk several unique self protection measures are needed for non-nuclear penetration of the Soviet Union. The first requirement is active defense. In high density target areas like the Ukraine, the bombers can provide their own mutual electronic support from large scale attacks to saturate and confuse the defense. In other locations, small groups of aircraft will face the defensive net essentially alone. In these circumstances, the passive ECM protection needs to be supplemented with some aggressive active counter measures like AGM-88 (HARM) anti-radiation missiles to suppress SAM sites, and long range air-to-air missiles (AAMRAAM) to neutralize the fourth generation fighter advantage. Cruise missiles with conventional warheads could be fired ahead of the force to eliminate critical radar/IR sites. Arming the bombers for self-defense is not a new concept. Air War College studies as early as 1951 called for self defense "anti-radar missiles" and extolled the virtues of taking the large bomber down to low level flight for survivability (3:61).

At the same time plans to create a new family of long range precision stand-off weapons provide the opportunity to remain outside the threat area and still disrupt vital facilities. Within their own intense defensive environment the European Security Study concluded, "The development of stand-off-delivery capabilities deserves high priority" (12:121). The multiple targeting capability of stand-off weaponry will further increase survival by adding to the defensive systems confusion. Such precision weaponry will also permit expanding the target attacks to more completely disrupt the Soviet economy and the military

resupply effort. Furthermore the cruise missile could also be used to attack soft targets like rail yard recovery and repair crews during daylight hours to sustain 24-hour pressure on the enemy.

Finally, when the aircraft escape Soviet air space, the audacity of their actions may well provoke extensive counterattacks on forward operating locations. While the aircraft are at their most vulnerable moments in the refueling and rearming process, extended air base defense, passive protective measures and additional fighter support will be required from NATO to minimize the ground threat to the B-52s.

In summary, the force employment considerations support the original concept of complementing current NATO tactical airpower employment philosophy with a strategic aerospace offensive and deep interdiction campaign. The open source literature provides a consistent picture of Soviet economic vulnerability in critical industries like steel, oil, power, and rail. A small force can attack the most important parts of these systems within the anticipated duration of a fast moving European war, even if aircraft attrition significantly exceeds historical loss rates. The present plan to dedicate 15 bombers to conventional operations with additional dual role aircraft added in a crisis, 15 missions produce sufficient sorties to cover the identified 150 targets. The spacing between each of the 15 missions is the key operational variable. Significantly shortening the cycle between flights would impact crew preparation for the next mission. In the World War II European Theater, keeping the long range pressure on the enemy eventually lead to manning each aircraft with two crews.

In conclusion, the strategic aerospace offensive and deep interdiction attack can destroy important targets located beyond the range of tactical airpower. The NATO theater commander should employ long range heavy bomber forces in these deep areas where no other aircraft can provide consistent attacks. The B-52 and other strategic aircraft offer the best conventional alternative for more effective deterrence in the European Theater when the USSR must consider the costs of replacing high value targets within its own borders. This campaign will start to limit enemy options as far from the battlefield as possible, and force resources to be diverted into repairs and defense. The proposed attacks on the most costly elements of the Soviet industrial base and logistics network directly influence the Warsaw Pact ground war and place essential sectors of their economy at risk. The priority of air attacks and the conditions for increasing aircraft survival are key elements in enhancing force effectiveness. The parallel between these Soviet targets and the systems chosen by Gen Hansell for the attack on Germany are very clear because the vital elements of an industrial economy remain fairly constant.

Overall, the strategic aerospace offensive and deep interdiction campaign maximizes the value of the long range bomber in extending the conventional battlefield and partially redresses the conventional force imbalance which threatens peace. As Secretary Weinberger forecast, "Nothing could so enhance the prospects for peace as Soviet acceptance of the proposition that they can achieve no significant exploitable military advantage over us" (44:59).

## BIBLIOGRAPHY

### A. FORCE EMPLOYMENT CONCEPTS AND THE USSR

1. Abernathy, John B., Maj, USAF, et al. Air Interdiction Analysis. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1972.
2. Abernathy, John B., Lt Col, USAF, and Jaquith, Roger H., Lt Col, USAF. Air Power Doctrine Study: Air Interdiction. Air War College Report No. 5830, Air University, Maxwell Air Force Base, Alabama, 1976.
3. Baker, James B., Col, USAF. Some Methods for Improving the Long Range Bomber's Defenses. Research study prepared at the Air War College, Air University, Maxwell Air Force Base, Alabama, 1951.
4. Bingham, Price T., Lt Col, USAF. Air Power and the Defeat of a Warsaw Pact Offensive: Taking a Different Approach to Interdiction in NATO. Center for Aerospace Doctrine, Research, and Education, Maxwell Air Force Base, Alabama, 1986.
5. Boyd, Darwin D., Major, USAF. Need for an Improved Non-Nuclear Force within NATO. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1971.
6. Chew, Robert S., CDR, USN. Principles of Aerial Interdiction. Air War College Report No. 3316, Air University, Maxwell Air Force Base, Alabama, 1967.
7. Clark, Ronald W. The Role of the Bomber. New York: Thomas Y. Crowell Co., 1977.
8. Compton, James R., Maj, USAF, et al. Air Interdiction Campaign Planning. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1973.
9. Davis, Benie L., Gen, USAF. "Indivisible Air Power." Air Force Magazine, March 1984, pp. 46-52.
10. Deane, Michael J. The Role of Strategic Defense in Soviet Strategy. Miami, Florida: Advanced International Studies Institute, University of Miami, 1980.
11. Drew, Adrian E., Lt Col, USAF. The Role of Air Interdiction in Limited War Concepts of Employment. Air War College Thesis No. 2723, Air University, Maxwell Air Force Base, Alabama, 1965.
12. European Security Study Commission. Strengthening Conventional Deterrence in Europe: Proposals for the 1980s. The American Academy of Arts and Sciences. Boston: Nimrod Press, 1983.

## CONTINUED

13. Garriss, Jack R., Col, USAF. Evolution of the USAF Senior Officer Combat Employment Course. Air War College Report AU-AWC-86-074, Air University, Maxwell Air Force Base, Alabama, 1986.
14. Halloran, Richard. "Plan to Re-equip B-52's is Proposed." New York Times, 18 September 1987, p. 7.
15. Hansell, Haywood S. Jr., and Hansell, Haywood S. III. US Strategic Aerospace Power. Unpublished paper prepared for the Joint Flag Officers' Warfighting Course, Center for Aerospace Doctrine, Research, and Education, Air University, Maxwell Air Force Base, Alabama, 1987.
16. Hemsley, John. Soviet Troop Control: The Role of Command Technology in the Soviet Military System. New York: Brassey's Publishers Limited, 1982.
17. Hines, John G., Lt Col, USAR, and Petersen, Phillip A. "The Soviet Conventional Offensive in Europe." Military Review, April, 1984, pp. 2-29.
18. James, Irving L. Air War and Emotional Stress. RAND Corporation. New York: McGraw Hill Book Co., 1951.
19. Jenkins, Frank R., Col, USAF. Development of Interdiction Doctrine and Strategy in the USAF: Post World War II. Air War College Report No. 94, Air University, Maxwell Air Force Base, Alabama, 1977.
20. Johnson, A. Ross, Dean, Robert W., and Alexiev, Alexander. East European Military Establishments: The Warsaw Pact Northern Tier. New York: Crane, Russak & Co., 1982.
21. Kennett, Lee. A History of Strategic Bombing. New York: Charles Scribner's Sons, 1982.
22. Kirtley, Robert L., Lt Col, USAF. Night Interdiction, the Key to Future Counterinsurgency. Air War College Report No. 5312, Air University, Maxwell Air Force Base, Alabama, 1974.
23. Kohn, Richard H. and Harahan, Joseph P., ed. Air Interdiction in World War II, Korea, and Vietnam. Washington, DC: Office of Air Force History, 1986.
24. Littman, Joel M., Maj, USAF. Counter Blitzkrieg Targeting. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1979.
25. Lonie, Frank R., Wing Commander, RAAF. Air Interdiction: Vietnam in Perspective. Air War College Report No. 5818, Air University, Maxwell Air Force Base, Alabama, 1975.

## CONTINUED

26. McDow, Richard M., Maj, USAF. Air Interdiction's Targeting Priorities. Air Command and Staff College Report No. 85-1805, Air University, Maxwell Air Force Base, Alabama, 1985.
27. Mustin, Thomas M., Lt, USN. Optimal Allocation of Air Strikes for Interdiction of a Transportation Network. Research study prepared at the Naval Post Graduate School, Providence, Rhode Island, 1967.
28. O'Berry, Carl G., Col, USAF. Optimizing Second Echelon Interdiction in Central Europe. Air War College Report No. AU-AWC-82-151, Air University, Maxwell Air Force Base, Alabama, 1982.
29. Price, Alfred. Air Battle Central Europe. New York: Free Press, 1986.
30. Quinn, James D., Maj, USAF. Soviet Military Thought: A Primer. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1976.
31. Remnek, Richard B. A Possible Fallback Counter Offensive Option in a European War. Center for Aerospace Doctrine, Research, and Education Report No. AU-ARI-CP-85-5. Air University, Maxwell Air Force Base, Alabama, 1985.
32. Sallagar, F. M. Operation Strangle (Italy, Spring, 1944), A Case Study of Tactical Air Interdiction. RAND Corporation Report R-851-PR. Santa Monica California, 1972.
33. Summers, Charles M., Maj, USAF. Interdiction Concepts and Doctrine, 1954 through 1968. Air Command and Staff College Report No. AU-C-18-68, Air University, Maxwell Air Force Base, Alabama, 1968. DOWNGRADED TO UNCLASSIFIED.
34. The United States Strategic Bombing Survey. Overall Report: European War. Washington, DC: US Government Printing Office, 1945.
35. -----. The Effects of Strategic Bombing on the German War Economy. USSBS Vol 3. Washington, DC: US Government Printing Office, 1945.
36. Ulsamer, Edgar. "Bombers for the Battlefield." Air Force Magazine, Jan 1987, p. 86-87.
37. US Department of the Air Force. Basic Aerospace Doctrine of the US Air Force. AF Manual 1-1. Washington, DC: US Government Printing Office, 1984.
38. -----. An Introduction to Air Force Targeting. AF Pamphlet 200-17. Washington, DC: US Government Printing Office, 1978.

## CONTINUED

39. US Army War College. Soviet Armed Forces Reference Text 1986-87. Carlisle Barracks, Pennsylvania, 1986.
40. US Department of Defense. Soviet Military Power 1987. Washington, DC: US Government Printing Office, 1987.
41. Walker, J. R., Air Vice Marshall, RAF. Air to Ground Operations. London: Brassy's Defense Publishers, 1987.
42. Walker, Robert G., Lt Col, USAF. Through the Looking Glass: An Analysis of Soviet Combined Arms. Air War College Report No. WPO08-80, Air University, Maxwell Air Force Base, Alabama, 1980.
43. Warden, John A., Col, USAF. The Air Campaign. National War College Strategic Study, National Defense University, Washington, DC, 1986.
44. Weinberger, Caspar. "US Defense Strategy." Foreign Affairs. Spring 1986.
45. Wolk, Herman S. Strategic Bombing: The American Experience. Manhattan, Kansas: MA/AH Publishing, Kansas State University, 1981.

### B. USSR - GENERAL.

46. Cole, J. P. A Geography of the USSR: The Background to a Planned Economy. London: Butterworth's, 1970.
47. -----. Geography of the Soviet Union. London: Butterworth's, 1984.
48. Crowson, Phillip. Minerals Handbook, 1984-85. Houston, Texas: Gulf Publishing Co., 1984.
49. Lawrence, Richard K. and Dresch, Francis W. National Entity Survival: Measure & Countermeasure. Menlo Park, California: Stanford Research Institute, 1971.
50. Novosti Press Agency. Soviet Economy Today. Westport, Connecticut: Greenwood Press, 1981.
51. Scherer, John L., ed. USSR Facts & Figures Annual. Gulf Breeze, Florida: Academic Press International, Volume 9, 1985.
52. Scrivener, Robert. USSR Economic Handbook. London: Euromonitor Publications, 1986.
53. Trembl, Vladimir G., ed. Studies in Soviet Input-Output Analysis. New York: Praeger Publishers, 1977.

## CONTINUED

54. Vienna Institute for Comparative Economic Studies. COMECON Data 1985. New York: Greenwood Press, 1986.
55. Woods, Stan. Weapons Acquisition in the Soviet Union. Aberdeen, Scotland: Center for Defense Studies, No. 24, 1982.
- C. ENERGY SYSTEMS AND THE USSR
56. Bean, Richard L., et al. Transformers for the Electric Power Industry. Westinghouse Engineering Staff. New York: McGraw Hill Company, 1959.
57. Blume, L. F., et al. Transformer Engineering. General Electric Engineering Staff. New York: McGraw Hill Company, 1950.
58. Campbell, Robert W. Soviet Energy Technologies. Bloomington, Indiana: Indiana University Press, 1980.
59. Dienes, Leslie and Shabad, Theodore. The Soviet Energy System. Washington, DC: V. H. Winston & Sons, 1979.
60. Deutsch, Robert W. Nuclear Power: After Chernobyl. Colombia, Maryland: GP Courseware, Inc., 1981.
61. Edison Electric Institute. Electric Power Development in the USSR, 1963. New York: Edison Electric, 1964.
62. Edmonds, Jae and Reilly, John M. Global Energy: Assessing the Future. New York: Oxford University Press, 1985.
63. Gibbs, J. B. Transformer Principles and Practice. New York: McGraw Hill Company, 1950.
64. Hewett, Edward A. Energy Economics and Foreign Policy in the Soviet Union. Washington, DC: The Brookings Institution, 1984.
65. Lovell, Alfred H. Generating Stations: Economic Elements of Electrical Design. New York: McGraw Hill Book Company, 1951.
66. Lundy, Wilson T., Maj, USAF. Enhanced Automatic Control of Electrical Power Systems. Air Command and Staff College Report No. 83-1475, Air University, Maxwell Air Force Base, Alabama, 1983.
67. Ramberg, Bennett. Destruction of Nuclear Facilities in War. Lexington, Massachusetts: D. C. Heath & Company, 1980.
68. Rosslvn, J. Power Transformers. New York: Chemical Publishing Company, 1941.

## CONTINUED

69. Shimkin, Demetri B. The Soviet Mineral Fuels Industries, 1928-1958: A Statistical Survey. Washington, DC: US Department of Commerce, Foreign Analysis Division, Series P-90, No. 19, 1962.
70. Wilson, David. The Demand for Energy in the Soviet Union. London: Croom Helm, LTD., 1983.

### D. TRANSPORTATION AND THE USSR

71. Beckmann, Martin, et al. Studies in the Economies of Transportation. New Haven: Yale University Press, 1956.
72. Disney, Charles P. and Leggett, Robert F. Modern Railroad Structures. New York: McGraw Hill Book Company, 1949.
73. Estep, Raymond. Transportation in the Soviet Union. Air University Documentary Research Study No. 30, Maxwell Air Force Base, Alabama, 1951.
74. Hammond, Robert. Railways in the New Air Age. New York: Oxford University Press, 1964.
75. Hunter, Holland. Soviet Railways Since 1940. Birmingham, United Kingdom: University of Birmingham, 1950. Reprinted from Bulletins on Soviet Economic Development, No. 4.
76. -----. Soviet Transportation Policy. Cambridge, Massachusetts: Harvard University Press, 1957.
77. -----. Soviet Transport Experience: Its Lessons for other Countries. Washington, DC: The Brookings Institution, 1968.
78. Jane's World Railways 1982-83. London: Jane's Publishing Company, Limited, 24th Edition, 1982.
79. King, Dorothy A. Soviet Transportation. Research study prepared at the US Army Institute of Advanced Russian Studies, Oberammergau, Germany, 1961.
80. Kretzschmann, Wilhelm. The Reconstruction of the Railroads in the Western Theater of War. Berlin: E. S. Mittler & Sons, 1922.
81. Raymond, William G. The Elements of Railroad Engineering. New York: John Wiley & Sons, 1911.
82. Rudzki, Adam. Railroad Systems in Captive Europe. New York: Mid-European Studies Center, No. 13, 1954.
83. -----. Roads, Waterways, and Seaports of Captive Europe. New York: Mid-European Studies Center, No. 15, 1954.

## CONTINUED

84. Tsarenko, A. P. Railroads and Trains. Washington, DC: Translation by US Department of Commerce Technical Services, 1963.
85. United Nations Economic Commission for Europe. Annual Bulletin of Transportation Statistics for Europe, 1969. New York: United Nations, Volume XXI, 1970.
86. Van Fleet, James A., General, USAR. Rail Transport and the Winning of Wars. Washington, DC: Association of American Railroads, 1956.
87. Westwood, John. Railways at War. San Diego, California: Howell North Books, 1980.
88. Westwood, J. N. Soviet Railways Today. New York: Citadel Press, 1964.
89. Whittaker, J. R. Containerization. London: Hemisphere Publishing Corporation, 1975.
90. Wohl, Paul and Albitreccia, A. Road and Rail in Forty Countries. London: Oxford University Press, 1935.

### E. INDUSTRY AND THE USSR

91. Amann, Ronald and Cooper, Julian. Industrial Innovation in the Soviet Union. New Haven, Connecticut: Yale University Press, 1982.
92. Darmstadter, Joel, et al. How Industrial Societies Use Energy. Baltimore, Maryland: Johns Hopkins Press, 1977.
93. Day, Donald, Maj, USAF. Evolution of the Soviet Military-Industrial Complex. Research study prepared at the Air Command and Staff College, Air University, Maxwell Air Force Base, Alabama, 1975.
94. Dewdney, John C. The USSR: Studies in Industrial Geography. Boulder, Colorado: Westview Press, 1976.
95. Fallenbuehl, Zbigniew M., ed. Economic Development in the Soviet Union and Eastern Europe, Volume I. New York: Praeger Publishers, 1975.
96. Gill, Timothy D., Col, USAF. Industrial Preparedness: Breaking with an Erratic Past. Washington, DC: National Defense University Press, 1984.
97. Hanson, Phillip and Hill, Malcolm R. "Soviet Assimilation of Western Technology." Soviet Economy in a Time of Change. Joint Economic Committee of the 96th Congress. Washington, DC: US Government Printing Office, 1981.

## CONTINUED

98. Hutchings, Raymond. Seasonal Influences in Soviet Industry. London: Oxford University Press, 1971.
99. Jasny, Naum. Soviet Industrialization, 1928-1952. Chicago: University of Chicago Press, 1961.
100. Jensen, Robert G., Shabad, Theodore, and Wright, Arthur W., eds. Soviet Natural Resources in the World Economy. Chicago: University of Chicago Press, 1983.
101. Joint Economic Committee, 97th Congress of the United States. USSR: Measures of Economic Growth and Development 1950-1980. Washington, DC: US Government Printing Office, 1982.
102. Liebrez, Marilyn L. Transfer of Technology, US Multinationals and Eastern Europe. New York: Praeger Publishers, 1982.
103. National Industrial Conference Board. Damage Control in Wartime. Washington, DC: Studies in Business Policy, No. 53, 1951.
104. US Senate. Subcommittee on International Finance and Monetary Policy. Hearings on East-West Trade and Technology Transfer, 14 April 1982. Washington, DC: US Government Printing Office, 1982.

### F. CENTRAL INTELLIGENCE AGENCY REFERENCE MAPS.

105. "Czechoslovakia", Serial No. 501820, May, 1974.
106. "German Democratic Republic", Serial No. 501041, July 1973.
107. "Hungary", Serial No. 501074, January 1973.
108. "Poland", Serial No. 503478, October 1977.
109. "Romania", Serial No. 76858, July 1970.
110. "Soviet Union", Serial No. 1800598, March 1986.
111. "USSR: Railroads", Serial No. 502174, April 1976.
112. "USSR: Industry & Resources", Serial No. 504395, August 1981.

## APPENDIX

TARGET	DIMENSION (FT)	POTENTIAL AREA DAMAGED (SQ FT)	B-17	B-52	B-1/B-2
TRANSFORMERS	500 X 500		49	2	
RAILROAD YARD	500 X 3000	600,000	152	5	
	1000 X 3000	1,200,000	169	8	
	1000 X 5000	2,000,000	257	13	
INDUSTRIAL FACILITY	800 X 2000	640,000	63	3	
	1000 X 3000	1,000,000	88	5	
	1000 X 5000	2,000,000	134	7	7
	2000 X 5000	4,000,000	182	13	11
	2000 X 8000	6,000,000	277	19	13
	4000 X 12000	19,000,000	678	53	34

TABLE II. SORTIES REQUIRED FOR 40% FRACTIONAL COVERAGE OF TARGET

(UNCLASSIFIED Sources: Bomb effectiveness-34:--; 35:--; 100:--; B-17 tactics-15:--; 7:--; 21:--; CEP data -34:--; 35:--; 15:--)

INDUSTRY	MONTHS OF PLANNING AND CONSTRUCTION		
	LARGE	PLANT	SMALL
BLAST FURNACES & STEEL MILLS	31.5		20
PETROLEUM REFINING	31.5		17.5
ALUMINUM ROLLING	25		14
STEAM ENGINES AND TURBINES	29		17
INTERNAL COMBUSTION ENGINES	26		15
INDUSTRIAL ORGANIC CHEMICALS	31.5		17
ALKALIES AND CHLORINE	31.5		22
TRANSFORMERS	24.5		12
ELECTRIC MOTORS, GENERATORS	21		12
ELECTRIC MEASURING INSTRUMENTS	15		8
ELECTRIC INDUSTRIAL CONTROLS	20		9
SULFURIC ACID	17		8

TABLE III. ESTIMATES OF INDUSTRIAL CONSTRUCTION. (49:--)





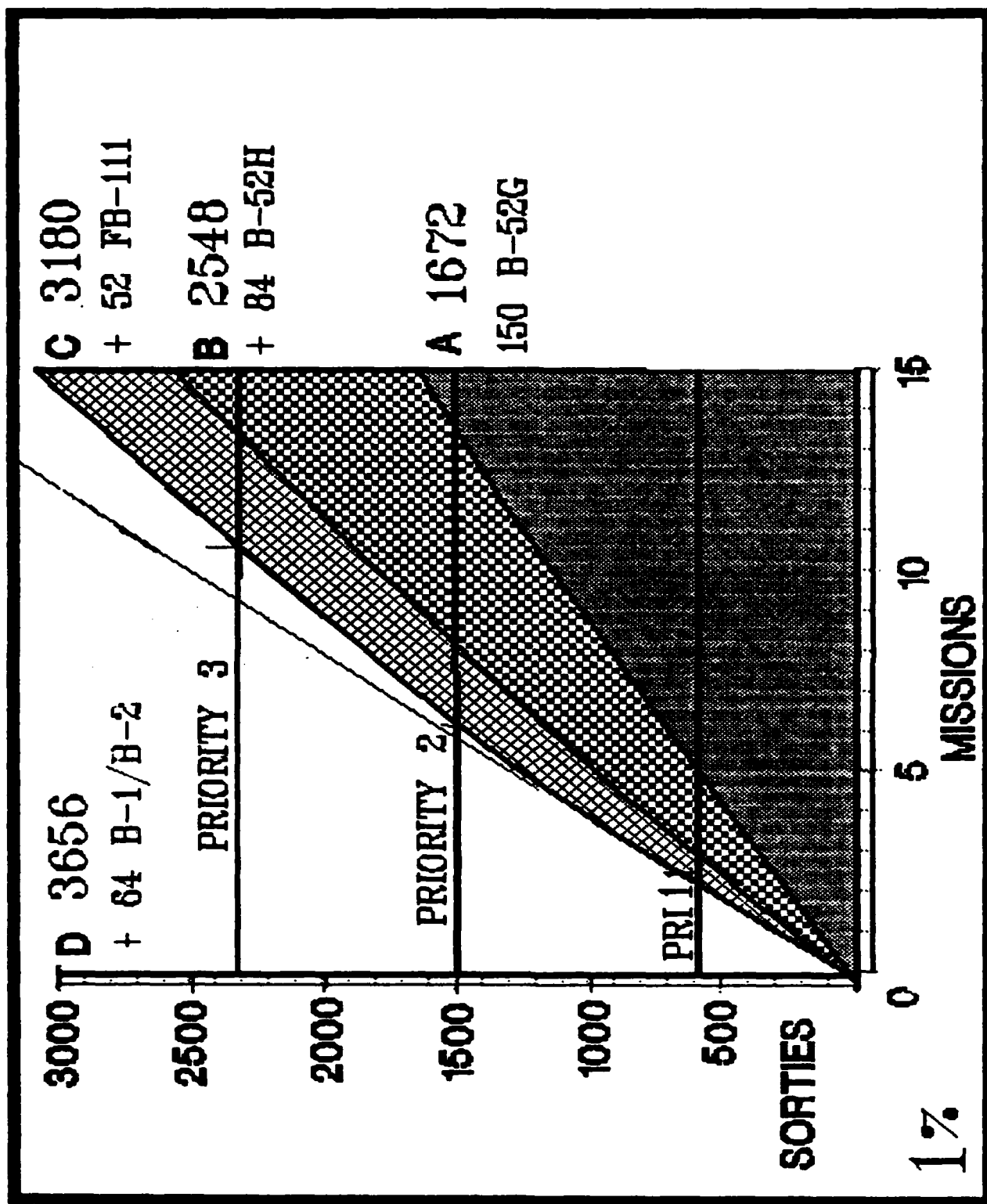


FIGURE 4. Sortie Requirements, 1%

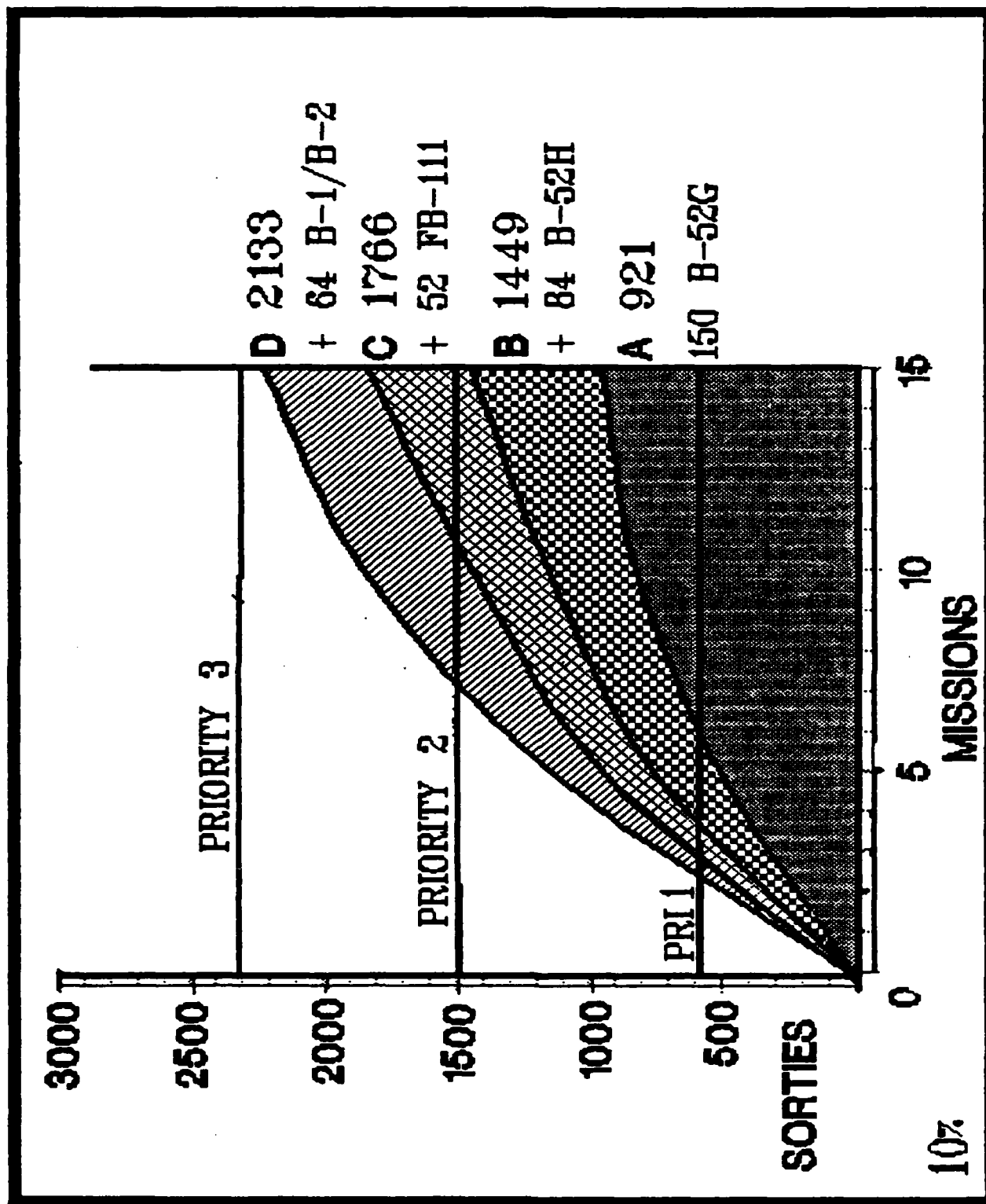


FIGURE 5. Sortie Requirements, 10%

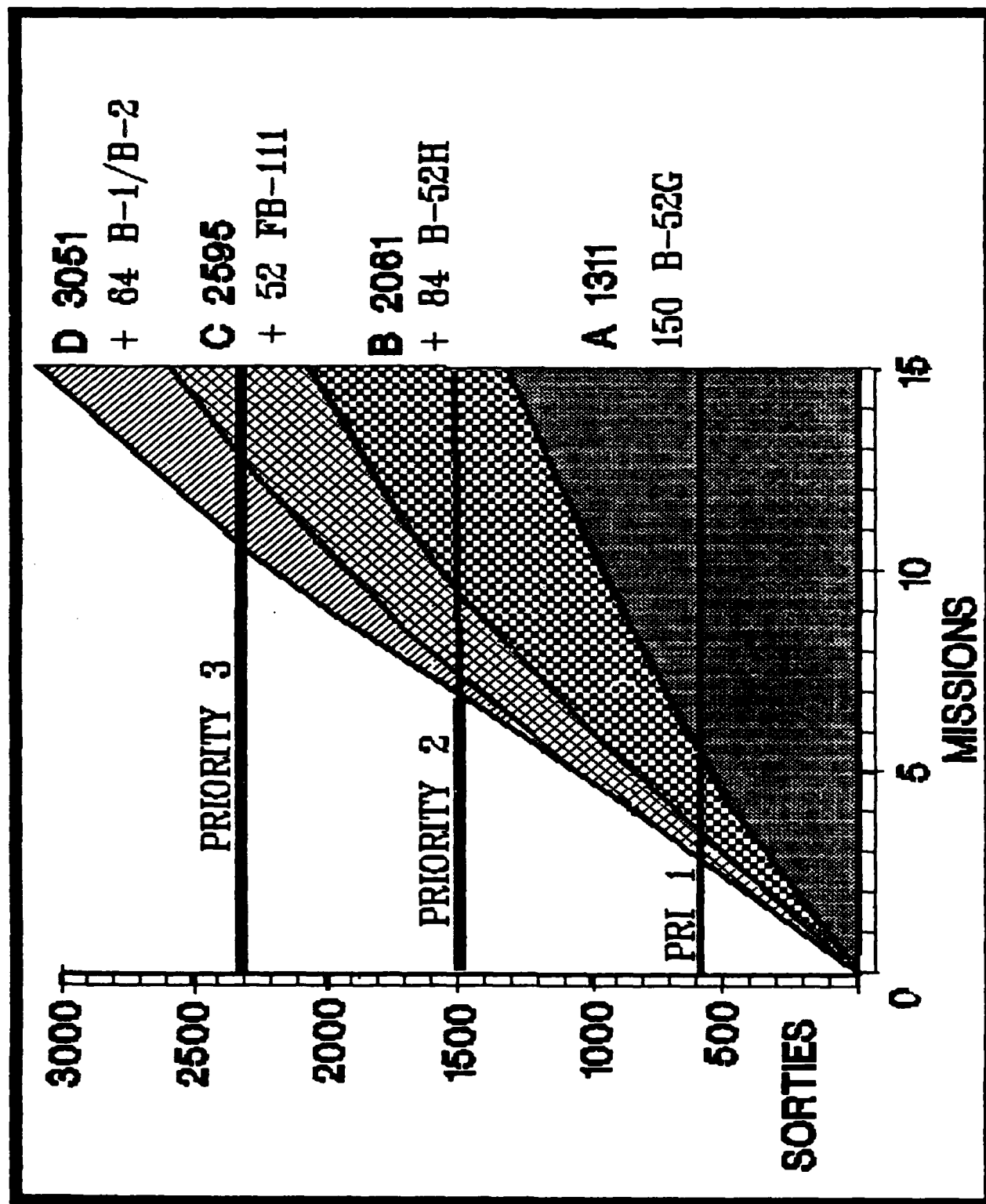


FIGURE 6. Sortie Requirements, 4%

END

DATE

FILMED

DTIC

JULY 88